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APPLICATION OF OPEN-SOURCE ENTERPRISE INFORMATION SYSTEM MODULES: AN EMPIRICAL STUDY

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APPLICATION OF OPEN-SOURCE ENTERPRISE INFORMATION SYSTEM MODULES: AN EMPIRICAL STUDY

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APPLICATION OF OPEN-SOURCE ENTERPRISE INFORMATION SYSTEM MODULES: AN EMPIRICAL STUDY

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Although there have been a number of studies on large scale implementation of proprietary enterprise information systems (EIS), open-source software (OSS) for EIS has received limited attention in spite of its potential as a disruptive innovation. Cost saving is the main driver for adopting OSS among the other possible benefits including security and reliability, transparency of development process, etc. Due to the costly implementation of proprietary EIS, small- and medium-sized organizations have given attention to OSS as an alternative. OSS EIS can also help create a competitive advantage by enabling organizations to customize their information systems by modifying the open-source software codes without the dependency on vendors.

Prior OSS related studies focused mostly on the desktop software, database management systems (DBMS), web server software, and operating systems (OS) to exploit the motivation of OSS developers, social structures, collaborations in OSS development communities, etc. The present research project conducted a confirmatory analysis on enterprise application built by open-source communities by adopting an information system success model that primarily relies on constructs that consists of user perspectives on OSS EIS that organizations have adopted.

This research consists of a two-phase qualitative/quantitative mixed method. The first phase investigates the frequencies of EIS modules that have been developed in OSS communities to find the most widely applied functions of OSS EIS. The second phase of the research examined the success factors of OSS EIS based on an IS success model. The study used a sample of OSS EIS users. Users of popular OSS EIS were surveyed about the quality of the system, the information from the system, the community service, the user satisfaction, individual net benefits, and the organizational net benefits. The results suggest removing several constructs entirely from the model proposed by this research and building a new simplified OSS EIS success model.

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CHAPTER ONE

INTRODUCTION

"Once openness is adopted as a business strategy then participation and collaboration naturally follow (Lee and Olson 2010)."

1.1 OVERVIEW

The advanced technology of the Internet that continuous to expand, the cheaper costs of hardware and telecommunication, and active participation of users through Web 2.0 are just some of the factors that contribute to the flood of information inundating society today. It has become increasingly important for firms to collect raw data, transform it into valuable information, and analyze the information for better decision making in the competitive global market. Firms continuously create transaction data 24/7 globally, where environmental resources and constrains including governments, competitors, customers, and cultures are constantly changing. Lee and Olson (2010) defined globalization as "… the development of connected world, that is much more open and interdependent." In the fast-moving business environments open to global competition, sustainable advantage requires unique and difficult-to-replicate dynamic capabilities (Teece, 2007).

These capabilities are necessary to sustain superior enterprise performance in an open economy with rapid innovation and globally dispersed sources of invention, innovation, and manufacturing capability. Firms not only adapt to business ecosystems, but also shape them through innovation and through collaboration with other enterprises, entities, and institutions. Iansiti and Clark (1994) found that integration capability was associated with positive enterprise performance, which demonstrates the importance of knowledge integration skills. In fast-paced environments, firms must have considerable autonomy (to make decisions rapidly) but remain connected to activities that must be coordinated (Porter, 1996). As a result, firms need to find the best industry practices to manage the growing volume of information in a manner that is valuable to their businesses. For example, the firm's strategies can be kept congruent with environmental changes by developing considerable knowledge management (KM) systems through information systems (IS) support.

The development of enterprise-level IS has enhanced such dynamic capabilities of firms. The functionalities of such IS include enterprise resource management, customer and supply chain management, knowledge management, business intelligence, etc. (Laudon and Laudon, 2010). The enterprise information systems (EIS) have been an emerging trend of implementation to meet the needs of businesses in the 21st Century.

However, as Olson (2004) explained, implementing EIS software is typically too complex for in-house capability and very expensive, involving millions of dollars for vendor purchasing price, consultant expertise, in-house development, and user education. The large size of financial investment and its inherent risk make firms hesitate to invest in the system, especially for small- and medium-sized businesses (SMBs). Additionally, since EIS are widely applied by organizations, it is hard to gain competitive advantage through EIS implementation (Karimi et al., 2007). Organizations can customize EIS through open-source codes to fit their processes and gain competitive advantage (Jaisingh et al., 2008).

Recently, EIS vendors have realized that open-source software (OSS) offer capabilities, both as a source of content for vendors as well as a threat to the proprietary enterprise system market share from competitors based on OSS development or delivery (Grewal et al., 2006). Porter (1996) stated, "… new market entrants, unencumbered by a long history in the industry, can often more easily perceive the potential for a new way of competing. Unlike, incumbents, newcomers can be more flexible because they face no trade-offs with their existing activities."

OSS development involves voluntary participation of individuals in on-line communities to develop computer software codes. The underlying philosophy of OSS is to enhance software reliability and quality through independent peer reviews and rapid evolution of applications. With OSS, developers and users are free to utilize and modify OSS by accessing open codes. The zero-cost licensing structure of most open-source projects has opened up the acceptance of these products into a number of previously untapped markets. According to Serrano and Sarriegi (2006), three major reasons why OSS is advantageous to implement and maintain EIS are: (1) increased adaptability to match the business processes and local regulations; (2) decreased reliance on a single supplier; and (3) reduced costs to implement and maintain the system. Johansson and Sudzina (2008) also claimed that OSS EIS enable SMBs to implement EIS at a minimal cost which often is an impediment for EIS implementation in SMBs. Thus far, though, OSS EIS are not yet the main stream since few trustworthy organizations have shown success in implementing them.

The motivation for this research can be summarized as follows:

- Although implementing OSS EIS can result in competitive advantage for SMBs, there have been few empirical studies on the topic.
- Success factors of information systems and general OSS have been discovered in prior studies. A confirmatory analysis of enterprise-level OSS based on the existing IS success research frames can discover success factors of OSS EIS.

The significance of this research resides in confirming the success factors of OSS EIS implementation that may help SMBs to adopt appropriate EIS modules. Although there have been several studies on large scale implementations of proprietary enterprise software, OSS EIS development has received limited attention in spite of its potential as a disruptive innovation (Brydon and Vining, 2008).

Reviews of prior studies and the motivations described above resulted in the following research question: *How does OSS development penetrate the proprietary EIS market?*

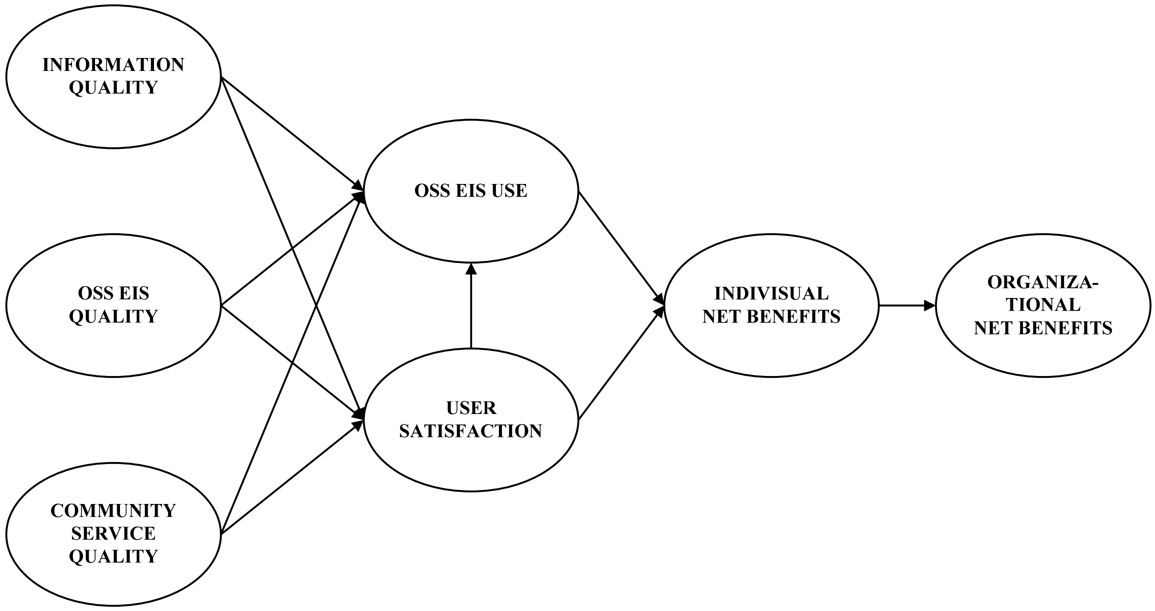
To answer this research question the following questions shall be examined:

1. Which EIS modules/functions are appropriate to be initiated and sustained for OSS development? (Development phase)
2. What are the major drivers of enterprise OSS modules for developing niche markets and reaching a critical mass of adopters? (Diffusion phase)

While there has been an abundance of literature on OSS, most studies on OSS success are qualitative or exploratory. An empirical study that measures OSS success would improve OSS use by delineating the success factors. This study develops an OSS EIS success model by expanding on a prior information systems success model by incorporating the characteristics of EIS and OSS.

An IS success model developed by DeLone and McLean (1992, 2003) has been applied to OSS in general to measure OSS success (Lee et al., 2009). The research model for this study is shown in Figure 1.1, which is distinguished from prior research due to the addition of two constructs, community service quality and organizational net benefits in accordance with the nature of enterprise-level information systems. This dissertation extends the application of the IS success model even further to enterprise software.

To evaluate the relationships shown in the model, end users of OSS EIS were surveyed about their perspectives on the use of OSS EIS based on their work experiences. The measurement instrument (survey of OSS EIS users) was developed by adopting existing validated instruments wherever possible. Summated scales for each variable were calculated from the survey item responses. The hypothesized relationships between variables were analyzed using structural equation modeling to assess the direction and strength of the relationships. The methodology used in this study is discussed in Chapter Three.



A modified model based on the studies by

DeLone and McLean (2003) and Lee et al. (2009)

Figure 1.1 OSS Success Model for Enterprise Information Systems

Results of this analysis are expected to confirm those from general IS success studies and find the relationships with the two additional variables of Community Service Quality and Organizational Net Benefits, which were intended to capture the properties of OSS and EIS. More specifically, the relative importance of each user perspective in relation to OSS EIS and the resulting impact on organization benefit will be shown. A comparison of the model and the typical IS success model by incorporating the two additional variables and by considering OSS EIS Use as a mediating variable will be discussed. Quantifying the strength and direction of these relationships has both theoretical and practical significance. From a research standpoint, this study will enrich the body of knowledge of OSS EIS development and provides a model that can potentially be applied to other OSS information systems development. For OSS developers and other practitioners including consulting firms, partners, and large firms who practice in-house OSS development, understanding the strength of various success factors aids in the decision-making processes in adapting OSS EIS for organizations. In addition, the study provides insight to the relationships between success factors and individual and organizational benefit. It may also help organizations who are pursuing the advantages of OSS select appropriate modules/functions of OSS EIS for their needs.

1.2 RESEARCH OBJECTIVE

The overall objective of this study is to examine the relationships between success factors identified in the literature as critical to open-source enterprise application and the net benefits of individuals and organizations that adopt OSS EIS for business purposes. Thus, the research purposes are: "What functions/modules of EIS are successful in OSS practice?" and "What are the success factors that influence the adaptation of OSS EIS?"

There are a number of on-line OSS development communities as shown in Table 1.1. Each community provides software development platforms for various types of OSS projects. OSS project has expanded the boundary from operating systems (OS) to database management systems (DBMS) to enterprise-level business software.

Rank	Name	Users	Projects	Bug Reports
1	**SourceForge**	2,600,000+	161,992	2,872,958
2	**Google Code**	Unknown	250,000+	Unknown
3	**GitHub**	205,000	90,000	Unknown
4	**CodePlex**	151,782	9,274	Unknown
5	**Tigris.org**	137,324	1,547	143,800
6	**Assembla**	170,000	60,000+	Unknown
7	**Launchpad**	1,061,601	17,140	498,464
8	**BerliOS**	43,062	5,367	Unknown
9	**Bitbucket**	35,000	19,100	Unknown
10	**TuxFamily**	2,381	1,844	Unknown

Table 1.1 Top 10 On-line OSS Communities

Enterprise applications include document management, office automation, network management, portal frame work, and so on, in addition to EIS that is the focal subject of this study. The study only examines the five major OSS enterprise applications. Laudon and Laudon (2010) defined EIS into five categories: enterprise resource planning (ERP) systems, supply chain management (SCM) systems, customer relationship management (CRM) systems, knowledge management (KM) systems, and business intelligence (BI) systems. Identification of such information system modules helps organizations, especially SMBs, find alternative ways to adopt EIS.

For software development, systems development life cycle (SDLC) or the waterfall model shown in Figure 1.2, which is the oldest form of SDLC suggested by Royce (1970), is the most widely applied process. According to Royce (1970), the waterfall model involves five steps: requirements specification, design, implementation, verification, and maintenance. To properly apply this model to software development, each step must be followed in sequential manner. Output from each step serves as input to the next step.

The requirements specification phase involves gathering information about customer's needs and defining the problem that the product is expected to solve. The design process involves defining the hardware and software architecture, designing data storage, choosing programming language, and designing user interface. The implementation step consists of constructing the product as per the design specification(s) developed in the previous step (Royce, 1970). Typically, this step is performed by a development team consisting of programmers, interface designers and other specialists, using tools such as compilers, debuggers, interpreters and media editors. In test/verification stage, both the individual components and the integrated whole are methodically verified to ensure that they are error-free and fully meet the requirements outlined in the first step (TechRepublic, 2006).

Lastly, the installation/maintenance stage involves preparing the system or product for installation and use at the customers' site. The maintenance stage occurs after installation, and involves making modifications to the system or an individual component to alter attributes or improve performance. These modifications arise either due to change requests initiated by the customer, or defects uncovered during live use of the system (TechRepublic, 2006).

These five steps can be viewed from the perspectives of the status of OSS project. The present study identified two distinct steps of the OSS project based on the proprietary Software (or System) Development Life Cycle (SDLC)/Waterfall model for research purpose as shown in Figure 1.2. The two phases that a typical OSS project goes through are: development and diffusion. Unlike in the proprietary software development process, in OSS users are not usually involved in the early stages, such as design and implementation. This lack of user involvement has noted as an issue in a prior study (Hughes and Cotterell, 1999).

In comparison to proprietary software, more OSS projects are ending their SDLC in the development phase. Not all OSS projects can be sustained in on-line community and diffused to fields, where users become actively involved. Lee et al. (2009) said, "… While there have been successful OSS projects, mostly with backend servers and Internet-related software, the number of failed or dormant OSS projects is also notable. In fact, according to the popular open source portal, SourceForge.net, most OSS projects have ended in failure: 58% do not move beyond the alpha developmental stage, 22% remain in the planning phase, 17% remain in the pre-alpha phase, and some become inactive."

The three milestones of the two phases, development and diffusion are: project initiative, project sustaining, and project adoption. Project initiative involves the first four stages of the Waterfall model: requirements specification, design, implementation, and verification, which are done in the development phase. Project adoption involves the last two steps of the Waterfall model: verification, and maintenance, which are done in diffusion phase. Project sustaining involves overlapped area between development and diffusion phases, including implementation, verification, and maintenance steps.

Toward this end, this study involves two research phases: (1) Identification of the most popular applications of OSS EIS modules by exploring on-line OSS communities shown in Table 1.1 to assess the proportion of EIS development among the various projects; and (2) A confirmatory analysis on the modified IS success model based on the user survey to analyze user perspectives on OSS EIS. The overview of this research is shown in Figure 1.3.

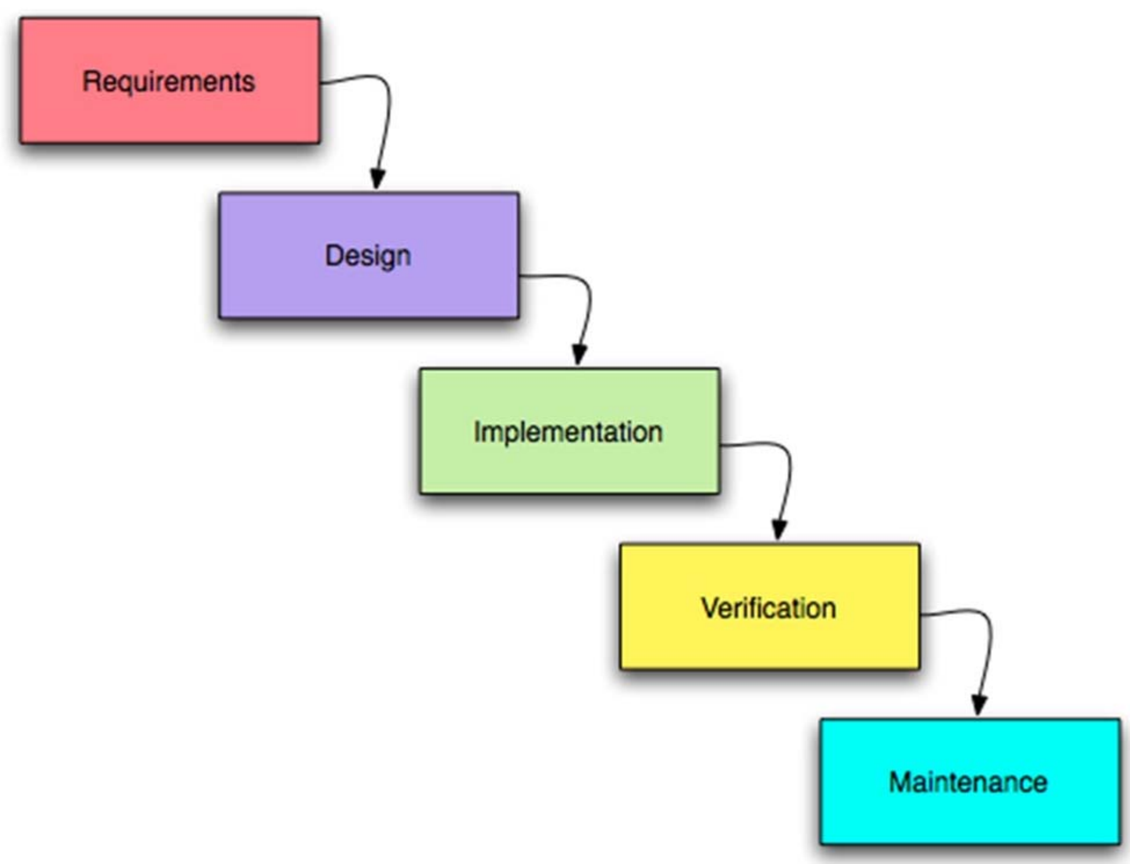


Figure 1.2 Waterfall Software Development Model (Royce, 1970)

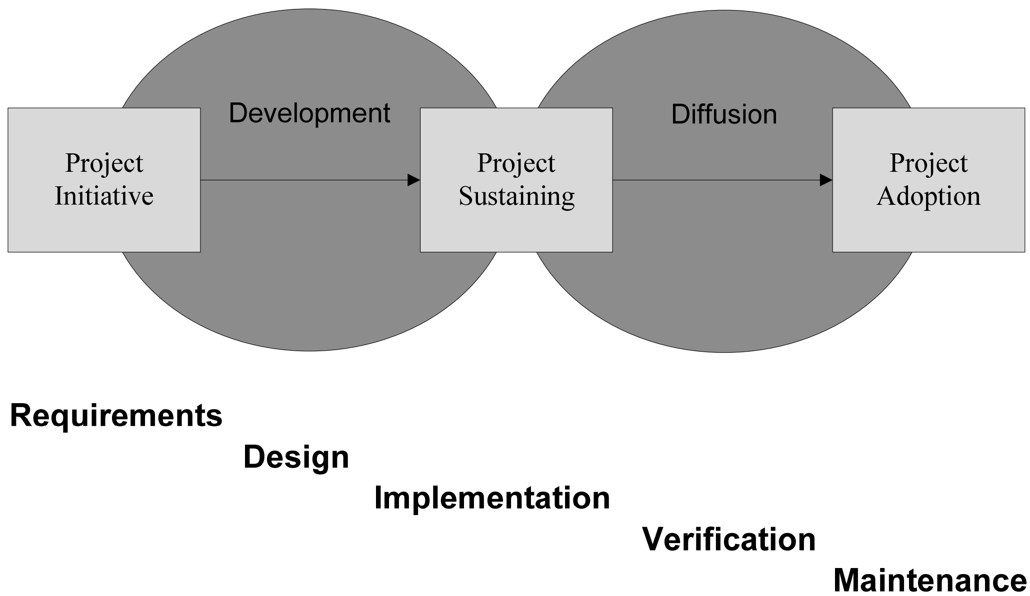


Figure 1.3 Research Overview

1.3 SIGNIFICANCE OF THE STUDY

The research published to date has developed the theoretical and conceptual relationships between success factors and individual or organizational net benefits for information systems. This study in the context of OSS EIS is an empirical extension that tests the relationships between user perspectives on the system and individual net benefits to assess their strength, direction, and impact on organizational net benefits. The results from the survey of end users are investigated to further the understanding of success factors of OSS EIS projects. Additionally, the evidence from this research may help practitioners make more informed decisions regarding employment of OSS EIS for their business.

1.4 STRUCTURE OF THE DISSERTATION

The dissertation is structured with five chapters; Introduction, Literature Review, Research Design and Methodology, Results and Discussion, and Summary and Conclusion.

Chapter One has introduced the topic of the study and discussed the general research objectives and research questions. Chapter Two presents a literature review on OSS EIS and information system success measures for OSS. Chapter Three outlines the research design and methodology employed in this study. It describes a research framework developed based on literature review. Hypotheses are developed and the variables used in the study are presented. Details of research design, the sample, and the survey instrument are also discussed. Chapter Four presents the results of statistical analyses and discussion. Chapter Five concludes the study by presenting the summary, limitations, and practical and academic contributions of the study.

CHAPTER TWO

LITERATURE REVIEW

"Information has no intrinsic value; any value comes only through the influence it may have on physical events. Such influence is typically exerted through human decision makers (Emery 1971, p.1)."

This chapter presents the literature review on OSS, EIS, and user perspectives on information systems. It consists of four sections. The first section presents a literature review on OSS in general. The second section reviews literature on EIS modules, describing the functions of EIS and the modules that vendors develop for firms. The section concludes by presenting a comprehensive set of EIS modules derived from prior studies. In the third section, a discussion of OSS EIS and its module development is presented. The fourth section presents the success factors of information systems. The existing literature in each of these areas, including their respective findings and implications are summarized in this chapter.

2.1 OPEN-SOURCE SOFTWARE

2.1.1 OPEN-SOURCE SOFTWARE DEFINED

OSS is computer software that is available in the source code form for which the source code and certain other rights normally reserved for copyright holders are provided under a software license that permits users to study, change, and improve upon it. OSS development projects are initiated by an individual or a small group with an interesting software idea that they themselves want for an intellectual or business reason (Subramanian and Soh, 2008). Raymond (1999) argued in his essay, *The Cathedral and the Bazaar,* the more widely available the source code is for public testing, scrutiny, and experimentation, the more rapidly all forms of bugs will be discovered. Raymond (1999) also claimed that an inordinate amount of time and energy must be spent hunting for bugs in the Cathedral model, since the working version of the code is available only to a few developers. On the other hand, OSS is a platform for the wisdom of the crowd. Sunstein (2006) suggested in his book about collective intelligence, "… a diverse collection of independently-deciding individuals is likely to make certain types of decisions and predictions better than individuals or even experts, draws many parallels with statistical sampling …" Boer et al. (1999) supports the arguments by suggesting that knowledge integration is the fusion and combination of knowledge from sources that are multiple, distributed and heterogeneous.

Lee and Olson (2010) argued the ability to access millions or potentially billions over the internet makes it far more valuable than a local area network. OSS development involves the voluntary participation of individuals on on-line communities that have no physical boundary. OSS is developed through open-source projects which are developed through group participation to modify and utilize the open software code for their own needs (Krogh and Hippel, 2006). OSS also works for the public interests by allowing developers and users utilize and modify OSS by accessing open code (O'Mahony, 2003; Roberts et al., 2006; Jaisingh et al., 2008).

Weber (2005) reviewed industry surveys seeking to identify why participants gave their time to such endeavors. One might naturally think of altruism, but that does not seem to be the explanation, as participants care a great deal about the credit for their work. They seem to emphasize feeling part of the technical community, using open-source participation to improve their programming skills as well as having fun. Software creators participate due to enjoyment, learning, reputation, and community membership (Lakhani and Wolf, 2005).

The underlying philosophy of OSS is to enhance software reliability and quality through independent peer review and rapid evolution of source code. Low cost is also a main driver of OSS implementation. OSS ERP's average implementation costs are at between one- sixth and one- third of the costs for typical proprietary ERPs (Lee and Olson, 2010). OSS has provided a number of successes. The most commonly understood open-source success is the Linux operating system, used by Dell, Compaq, and IBM, as well as many other firms. MySQL is an open-source database server. Apache web server leads over Microsoft IIS by a substantial margin. Sun Microsystems have long viewed OSS as a means to develop long-range market strength (Babcock, 2009). Other firms have been able to make OSS work, including Dell computers (Conry-Murray, 2009). According to Iansiti and Richards (2006), OSS is created by two clusters, the money-driven cluster and the community-driven cluster. IT vendors, such as Oracle and IBM, mainly focus on money-driven cluster and actively promote a proprietary product over an open source equivalent.

Open-source licenses often meet the requirements of the Open Source Definition suggested by Open Source Initiative (Open Source Initiative, 2010). OSI, an organization dedicated to promoting OSS, defines OSS in the following 10 criteria: (1) Free Redistribution – the license shall not restrict any party from selling or giving away the software. The license shall not require a royalty or other fees for such sale; (2) Source Code - the program must include source code in the preferred form in which a programmer would modify the program; (3) Derived Works - the license must allow modifications and derived works; (4) Integrity of The Author's Source Code - the license may restrict source-code from being distributed in a modified form *only* if the license allows the distribution of "patch files" with the source code for the purpose of modifying the program at build time; (5) No Discrimination Against Persons or Groups - the license must not discriminate against any person or group of persons; (6) No Discrimination Against Fields of Endeavor - the license must not restrict anyone from making use of the program in a specific field of endeavor; (7) Distribution of License - the rights attached to the program must apply to all to whom the program is redistributed without the need for execution of an additional license by those parties; (8) License Must Not Be Specific to a Product - The rights attached to the program must not depend on the program's being part of a particular software distribution; (9) License Must Not Restrict Other Software - the license must not place restrictions on other software that is distributed along with the licensed software; (10) License Must Be Technology-Neutral - No provision of the license may be predicated on any individual technology or style of interface.

2.1.2 OSS AND PROPRIETARY SOFTWARE

Davis (2009) surveyed 656 business technology professionals, 557 of whom used OSS. OSS was reported as pervasive in 17 percent of these firms, but was reported to have rather limited use by 68 percent. The primary barrier to adoption of OSS was cited to be lack of formal support, followed by lack of functionality and lack of financial stability of supporting vendors. Security and legal issues were reported to be of minor importance.

Economides and Katsamakas (2006) found that the OSS industry is more lucrative than proprietary software industry when adopters have weak needs for platform and strong needs for applications or customization. In this regard, there is now keen competition between OSS and closed software in the software market (Jaisingh et al., 2008). According to Lee and Mendelson (2008), the optimal strategies of the two software industries, commercial software and OSS, depend on both product timing and compatibility.

Network effects make compatibility a key competitive factor. Network effects also create an intense competitive environment, driving profits down if the technologies are incompatible. If OSS can establish itself first, the commercial firm is always better off mitigating the network effects by following the OSS lead and designing a compatible product. Sen (2007) also insisted that most OSS are late entrants to the market, already consisting of proprietary and its complementary/supplementary products. In order to attract users in this market, the OSS will have to be compatible with these existing complementary/supplementary products. Even in a situation where all consumers eventually adopt the proprietary software, the presence of OSS as a credible threat drives down prices, thereby increasing consumer surplus. Open source developers derive not only personal satisfaction from developing software but they also seek to maximize a measure of consumer surplus and therefore suffer if incompatibility splits the market.

Lee and Mendelson (2008) argued that with zero switching cost, open-source software does not gain a market-share advantage by being available first. However, the presence of OSS pushes the proprietary software firm to improve its product features and launch their products early. A firm considering open source development as an alternative to closed source development would need to carefully review the relationship between the software in question and the firm's other products. If the software is found to enhance the usefulness or quality of complementary products and/or if the users of the software and the users of the complementary product belong to the same network, the complementary software can be exploited (Haruvy et al., 2008).

2.2 ENTERPRISE INFORMATION SYSTEMS AND MODULES

The organizational benefits of an information system often depend on how they are implemented and utilized in addition to what functional attributes they possess (Markus, 1983; Robey and Boudreau, 1999). EIS are applications that focus on managing and integrating whole business processes including accounting, finance, manufacturing, human resources, and inventory management (Davenport and Brooks, 2004). The following sections describe functions/modules of each five major enterprise applications, ERP, SCM, CRM, KM, BI systems.

2.2.1 ERP SYSTEM MODULES

Business computing systems were initially applied to those functions that were easiest to automate and that called for the greatest levels of consistency and accuracy.

Davenport (1998) defined business functions potentially supported by ERP as shown in Table 2.1. The top five categories defined by Davenport (1998) include: financial function, human resources function, operations and logistics function, and sales and marketing function. Each function includes several modules. Financial function may include financial and accounting modules, such as accounts receivable and payable, cash forecasting, and cost accounting. Human resource function may include time accounting and payroll modules. Operations and logistics function includes inventory management, materials requirement planning, and purchasing modules. Sales and marketing function may include order management and sales planning. Olson (2004) argued that ERP systems in concept cover all computing for an organization to centralize data and computation and to remove the redundancy and inconsistency of data. However, proprietary ERP vendors sell their software in modules as shown in Table 2.2.

Financial	Human Resource	Operations and Logistics	Sales and Marketing
Accounts receivable and payable	Time accounting	Inventory management	Order management
Asset accounting	Payroll	Materials Requirement Planning (MRP)	Pricing
Cash forecasting	Personnel planning	Plant maintenance	Sales management
Cost accounting	Travel expenses	Production planning	Sales planning
Executive information systems		Project management	
Financial consolidation		Purchasing	
General ledger		Quality management	
Profitability analysis		Shipping	
Standard costing		Vendor evaluation	

Table 2.1 Business Functions Supported by ERP (Davenport, 1998)

Mabert et al. (2000) reported the extent of ERP module use by surveying 479 ERP users from the American Inventory and Inventory Control Society. Olhager and Selldin (2003) conducted a similar study by surveying 190 Swedish manufacturing firms. Another study by Katerattanakul et al. (2006) was done by surveying 306 Korean manufacturing firms. The results from the three studies are listed in Table 2.3. These studies found that the most frequently used module of ERP in the United States was financial and accounting (Mabert et al., 2000); materials management, production planning, and order entry in Sweden (Olhager and Selldin, 2003); and the modules related to the time-to-customer process in Korea (Katerattanakul et al., 2006).

The results from the similar studies show different ERP implementation practices in the three countries. Olhager and Selldin (2003) explained that Swedish firms are keener on using European, and in particular Swedish, ERP systems while the US study rank SAP, Baan and PeopleSoft as the most popular systems. (PeopleSoft acquired JD Edwards in 2003 and Oracle acquired PeopleSoft in 2005) Swedish firms typically implement more modules; all individual modules have a higher implementation frequency in the Sweden research except financial accounting, which is the most widely implemented module in the US. The study found that information speed, quality and availability improved but the information technology costs were not decreased, which were quite similar to those experienced in the US.

Functional Description	SAP	Oracle	People Soft	JD Edwards
Records sales orders and scheduled deliveries, customer information	Sales and Distribution	Marketing Sales Supply Chain	Supply Chain Management	Order Management
Purchasing and raw materials inventory, work-in-process. customer information	Materials Management	Procurement	Supplier Relationship Management	Inventory Management Procurement
Production Planning and scheduling actual production	Production Planning	Manufacturing		Manufacturing Management
Product inspections, material certifications ,quali ty control	Quality Management		Enterprise Performance Management	Technical Foundation
Preventive maintenance, resource management	Plant Maintenance	Service	Enterprise Service Automation	
Recruiting, hiring training ,payroll ,be nefits	Human Resources	Human Resources	Human Capital Management	Workforce Management

Table 2.2 Modules Offered by Leading Vendors (Brady et al. 2001)

Module	*Midwest US*	*Sweden*	*Korea*	*Mean*
Financial & Accounting (Fa)	91.5%	87.3%	92.5%	91.7%
Materials Management (Mm)	89.2%	91.8%	94.1%	91%
Production Planning (Pr)	88.5%	90.5%	91.5%	90.4%
Order Entry (Or)	87.7%	92.4%	90.5%	90.2%
Purchasing (Pu)	86.9%	93.0%	93.1%	90.2%
Financial Control (Fc)	81.5%	82.3%	85.0%	82.9%
Distribution/Logistics (Di)	75.4%	84.8%	85.9%	82.0%
Asset Management (Am)	57.7%	63.3%	81.4%	67.5%
Quality Management (Qm)	44.6%	47.5%	77.6%	60.2%
Personnel/Human Resources (Hr)	44.6%	57.6%	78.4%	56.6%
Maintenance (Ma)	40.8%	44.3%	72.2%	52.4%
R&D Management (Rd)	30.8%	34.2%	69.5%	44.8%

Table 2.3 Use of ERP Modules (Mabert et al., 2000; Olhager and Selldin, 2003; Katerattanakul et al., 2006)

2.2.2 SCM SYSTEM MODULES

SCM information systems (IS) are distinguished from other EIS in that they focus primarily on supply chain planning and execution rather than other functions such as human resources or accounting. The main idea of ERP was to centralize data and computation, so that data can be entered once in a clean form, and then be used by everyone in the organization (and even by supply-chain partners outside the organization) (Olson, 2004). According to the ERP study in Sweden done by Olhager and Selldin (2003), the set of modules requiring customization is similar to those in the US. Order entry was singled out as number one in the US study followed by distribution/logistics, production planning, and materials management. Thus, it seems that the supply chain process from suppliers through manufacturing to customer generally is important and needs some tailoring to support the needs of the individual enterprise and its relationship with supply chain partners.

Motivations for developing a hierarchical taxonomy for SCM IS include: there is no comprehensive classification of SCM IS modules due to the overlapping functionality in most SCM IS and due to their tendency to be configured differently for each implementation (Helo and Szekely, 2005); the ‘best-of-breed’ approach for EIS implementation complicates the process of matching organizational requirements to software functionality (Light et al. 2001); and overlaps in functionality among different SCM IS prevent the development of useful taxonomies using the traditional approach of grouping products into different categories. In the following sections, various SCM classifications are discussed.

2.2.2.1 GENOMIC CLASSIFICATION SCHEME

McLaren and Vuong (2008) developed a hierarchical classification scheme, which is the scheme utilized in this study for SCM classification. The taxonomy developed by McLaren and Vuong (2008) describes 83 major functional attributes that form five top-level categories: primary supply chain processes, data management, decision support, relationship management, and performance improvement as shown in Appendix A. A modified grounded theory approach was followed to help ensure the model constructs. The categories were derived from empirical descriptions of commercial SCM IS packages, rather than from purely theoretical constructs.

Using the hierarchical taxonomy, researchers and practitioners will be able to more accurately classify and describe SCM IS while providing greater detail on the functionality provided by specific SCM IS. The use of the qualitative analysis software facilitated the analysis of the approximately 1,800 pages of text. The study was limited to the seven most popular SCM IS packages. Although this ignores some specialized functionality in other niche SCM IS, limiting the scope to the "Big Seven" facilitated comparison and theoretical replication between the packages while reducing extraneous differences (Yin, 2003).

At the highest level, the attributes were organized into five categories as indicated before. These functional attributes should be viewed as the attributes that were prominent in the most commonly used SCM IS applications. Future research could include investigating more niche functionalities as appropriate.

2.2.2.2 OTHER CLASSIFICATIONS

AMR Research, Inc., a company providing supply chain and supporting technologies, classified SCM technologies by application segment in 2007 into 10 categories, including Warehouse Management (16%), Order Fulfillment (15%), Supply Chain Management Performance (14%), Production and Distribution Planning (12%), Demand Planning (11%), Transportation Management (11%), Inventory Optimization (7%), Service Parts Management and Planning (6%), Sales and Operation Planning (5%), and Global Trade Management (3%) (Kerr, 2009).

Most of these categories are inclusive in the top level of the genomic classification or the successive levels. Fawcett, Ellram, and Ogden (2007) suggested that operations processes must manage the same core set of decisions, which can be classified into two groups: design decisions and control decisions. The design decisions including Product Design, Process Design, Facility Layout and Facility Location are under the primary SCM of the genomic classification. The control decisions are also a subset of the genomic classification since they fit well under the rest of the categories. In comparison to the described categories, the study of genomic classification was based on the quite collective data and provides sufficient information to identify SCM IS modules for this study. Defining a comprehensive set of EIS modules is a necessary step that must be done prior to the present research for consistency. Both the content analysis in phase one and the confirmatory factor analysis in phase two of the research are performed based on the same EIS categories.

2.2.3 CRM SYSTEM MODULES

Porter's (1979) five competitive forces model provides a general view of the organization, its competitors, and the environment. The five competitive forces include traditional competitors, new market entrants, substitute products and services, suppliers, and customers. A profitable company depends in large measure on its ability to attract and retain customers (Laudon and Laudon, 2010). In a survey of 506 global CEOs, CEOs ranked customer loyalty and retention as their No. 1 management challenge (Rosenbleeth et al., 2002). Advanced information technologies, such as CRM systems, have forced firms to focus on managing customer relationships through meeting customer satisfaction to maximize revenues. Mass customization and personalization have been discussed in many studies as instruments of customer loyalty and retention. Mass customization and the corresponding approach of personalization have the potential to address competitive market requirements while improving a firm's profitability (Tseng and Pillar, 2003). Prior studies developed the instrument of customer-centric knowledge management (Stefanou et al., 2003; Alvert et al., 2004).

Colombo et al. (2004) defined eight CRM system modules. They classified CRM system modules into three main categories and then each main category has multiple sub-modules. The three main classifications are collaborative CRM system, analytical CRM system, and operational CRM system. The collaborative CRM system includes two sub-modules, channel management and call center/help desk. The analytical CRM system also includes two sub-modules data integration and data warehousing and knowledge management. Lastly, the operational CRM system includes four sub-modules, field, sales, marketing, and product management.

2.2.4 KM SYSTEM AND BI SYSTEM MODULES

Knowledge management systems facilitate the efficient and effective sharing of a firm's intellectual resources (Poston and Speier, 2005). KM systems refer to (generally IT based) systems for managing knowledge in organizations for supporting creation, capture, storage, and dissemination of information. KM systems are positively related to administrative and technical innovation performance (Huang and Li, 2009; Thornhill, 2006). Sher and Lee (2002) presented that KM systems contribute to the enhancement of dynamic capabilities and thus to the enhancement of business excellence and competitive advantages.

Laudon and Laudon (2010) defined KM systems as enterprise-wide systems for managing and distributing documents, graphics, and other digital knowledge objects; systems for creating corporate knowledge directories of employees with special areas of expertise; office systems for distributing knowledge and information; and knowledge work systems to facilitate knowledge creation. Other knowledge management applications use intelligent techniques that codify knowledge for use by other members of the organization and tools for knowledge discovery that recognize patterns and important relationships in large pools of data.

The last entity that the study considers as EIS is business intelligence systems. BI systems are designed to help individual users grapple with vast quantities of data as they make decisions about organizational processes (Watson et al., 2004). Once data have been captured and organized in data warehouses and data marts, they are available for further analysis. BI systems encompass a set of tools, techniques, and processes to help harness this wide array of data and allow decision makers to convert them to useful information and knowledge (Negesh, 2004). A series of tools enables users to analyze data in search of new patterns, relationships, and insights that are useful for guiding decision making. BI systems are tools for consolidating, analyzing, and providing access to vast amounts of data to help users make better business decisions. Principle tools for business intelligence include software for database query and reporting, tools for multidimensional data analysis (online analytical processing, OLAP), and data mining.

2.3 OSS EIS

Implementation of enterprise systems, such as EIS, requires a large amount of investment and its inherent risk makes firms hesitate to implement the system, especially for SMBs. Recently, as open-source projects became more popular, there have been some studies on OSS EIS. Lee et al. (2010) conducted a comparative study of proprietary and OSS ERP modules. They investigated Sourceforge.net, a community-driven OSS developing site that has 348,000 open source projects including EIS, business intelligence, and database management systems, among others. The study shows that OSS ERP projects are being developed more in supportive modules than value chain modules, which are opposite to the results from the proprietary studies as shown in Table 2.4.

The rankings of proprietary ERP modules were calculated based on the results from the three studies by Mabert et al. (2000), Olhager and Selldin (2003), and Katerattanakul et al. (2006). The rankings of ERP modules in proprietary market are almost opposite of the ranking of OSS modules. Even though OSS is disruptively innovative, it is the commercial vendors of enterprise systems that are still dominating the market for ERP main activities modules.

Rank	Proprietary EIS	OSS EIS
1	Materials Management	Maintenance
2	Purchasing	N/A
3	Financial & Accounting	Disagree
4	Order Entry	Complete ERP
5	Production Planning	Distribution/Logistics
6	Financial Control	Financial & Accounting
7	Distribution/Logistics	Personnel/Human Resource
8	Asset Management	Material Management
9	Personnel/Human Resources	Production Planning
10	Quality Management	R & D Management
11	Maintenance	Asset Management
12	R&D Management	Purchasing
13	--	Quality Management
14	--	Order Entry
15	--	Financial Control

Table 2.4 Proprietary ERP Implementations and OSS ERP Projects

Explanation can be that because large firms already have large financial investments and implemented the main-activities modules, they are reluctant to experiment and install new OSS modules. Large firms do not want to take high risk for such main modules of the value chain. They would rather like to get their toes in and experiment with OSS for the supportive modules of ERP and may want to see if there is a compatibility issue between the existing main-activities modules and OSS modules.

According to the work done by Park et al. (2002), manufacturing was the highest regarding proprietary ERP implementation with 71.7% among the industries of the respondents' organization. Damanpour (1992) studied about the relationship between organizational size and innovation. The size of firm is more positively related to innovation in manufacturing and profit-making organizations than in service and non-profit-making organizations. They also found that size is more strongly related to the implementation of proprietary system than to the initiation of innovation (OSS system) in organizations. These findings are consistent with the results of the comparison by Lee et al. (2010) and also induce a conclusion that large organizations are reluctant to adopt OSS EIS.

On the other hand, since OSS ERP is more affordable, SMBs are the ones which are more likely to try out the free software as an alternative of expensive proprietary ERP. There are, however, an increasing number of large firms using OSS EIS, such as Home Depot, Toyota, and Fidelity (Weber, 2005). This indicates that OSS EIS receives more focus than before. In recent years, the general OSS development model has gained significant momentum and is now generally considered a viable approach also in commercial settings (Ågerfalk and Fitzgerald, 2008). Because of its nature of virtuality and since anyone can joint any OSS project, the development of on-line community can be assumed to be global (Millar et al. 2005). Agerfalk and Fitzgerald (2008) in their study collected numerous instances of research that confirm the global nature of contributions to open source projects (Lakhani and Wolf, 2001; Ghosh et al., 2002; Dempsey et al., 2002; Robles-Martinez et al., 2001).

2.4 OSS EIS MODULES

This dissertation first identifies the extent of OSS EIS module use. To identify the OSS EIS modules that are frequently downloaded by users, the study investigated the top 10 on-line OSS communities shown in Table 1.1. A total of 1,240 OSS EIS projects were collected: 1,199 projects from SourceForge.net; 5 from GitHub; 35 from Launchpad; 1 from TuxFamily. Several items that describe each project were collected: title, description, number of download, and recommendation rate by users. Appendix C has a table that contains the entire lists of OSS projects collected for this research.

Based on the literature review presented in 2.2, this study develops a comprehensive set of EIS modules as shown in Table 2.5 that were used in the content analysis and the confirmatory analysis consistently. It consists of the following primary categories: ERP, CRM, and SCM, each category has sub categories. KM systems and BI systems are not shown in the top level because in many cases, they match with one of the subcategories of ERP, CRM, or SCM. The 1,240 OSS EIS projects collected from top 10 on-line OSS communities are categorized based on this set of modules and gives the extent of use. The survey on users reveals the actual use of OSS EIS modules. The two results are compared and discussed in Chapter 4.

- Enterprise Information Systems (ERP)
  1. Financial & Accounting
  2. Materials Management
  3. Production Planning
  4. Order Entry
  5. Purchasing
  6. Financial Control
  7. Distribution/Logistics
  8. Asset Management
  9. Personnel/Human Resources
  10. Quality Management
  11. Maintenance
  12. R&D Management

- Customer Relationship Management (CRM)
  1. Channel Management
  2. Call Center/Help Desk
  3. Data Integration/Data Warehousing
  4. Knowledge Management
  5. Field
  6. Sales
  7. Marketing
  8. Product Management

- Supply Chain Management (SCM)
  1. Delivery (transportation execution, invoicing)
  2. Make (to order, to stock, process manufacturing, discrete manufacturing, sales order processing, bill of materials, production control, inventory replenishment, order promising)
  3. Return
  4. Plan (demand planning, supply planning, service parts planning, supply and demand matching, optimize inventory, network design, production planning, transportation planning)
  5. Source (procurement, purchase order processing)
  6. Data Management (XML, RFID, EDI)
  7. Decision Support (optimization, reporting, modeling, forecasting, product lifecycle management, scenario analysis, simulations)
  8. Relationship Management (distributor, competitor, retailer, manufacturer, supplier)
  9. Performance Improvement (lean supply chain, performance analysis, collaboration, quality management)

Table 2.5 EIS Modules

2.5 IS SUCCESS MODEL

A large number of studies have been conducted to identify success factors of information systems. Prior studies have focused on various aspects of IS success for three decades (Matlin, 1979; Melone, 1990; DeLone and McLean, 1992; Bonner, 1995; Ballantine et al., 1996; Gable, 1996; Kapalan and Norton, 1996; Myers et al. 1998; Seddon et al, 1999; Irani and Love, 2000; Lin and Shao, 2000; Thatcher and Oliver, 2001; DeLone and McLean, 2002; Rai et al., 2002; Shin, 2003; DeLone and McLean, 2003; Gable et al., 2003; Sedera and Gable, 2004; Sabherwal et al., 2006; Gable et al., 2008; Lee et al., 2009).

Rai et al. (2002) assessed two main IS success models: DeLone and McLean (1992) and Seddon (1997). Their findings support DeLone and McLean's argument that IS success models need to be carefully specified in a given context. Shin (2003) investigated the effectiveness of the four IS success constructs, system quality, information quality, and service quality on user satisfaction in the context of data warehouse by employing a survey and interview. Sabherwal et al. (2006) developed a theoretical model combining four IS success constructs developed in prior studies. They added four user-related constructs: user experience with IS, user training in IS, user attitude toward IS, and user participation in the development of IS.

Irani and Love (2000) conducted a case study at a leading manufacturing organization during its adoption of a vendor-supplied MRPII. They developed technology management taxonomies that contributed to the successful MRP implementation. Seddon et al. (1999) developed an IS effectiveness matrix for conceptualizing IS success measurements in the two dimensions, the type of system and the type of stakeholder.

Thatcher and Oliver (2001) examined the impact of technology investment on various measures of performance, such as product quality, production efficiency, and firm productivity. Thatcher and Olivers's study (2001) evaluated IS investments post-implementation. Myers (1998) suggested a comprehensive IS success model by combining prior studies and adding a service quality dimension.

Gable et al. (2003) developed four measurement models and 27 instruments for assessing enterprise system success by employing an exploratory inventory survey followed by a confirmatory weights survey. The four measurement models are information quality, system quality, individual impact, and organizational impact. Sedera and Gable (2004) found the four distinct dimensions of IS success in the context of enterprise information systems – individual impact, organizational impact, system quality, and information quality.

Prior studies discussed here have heavily referred to DeLone and McLean's works (1992, 2002, 2003). The DeLone and McLean (1992) IS success model is most widely cited and has provided valuable contributions to the literature of IS success. DeLone and McLean (1992) introduced their first edition of a comprehensive taxonomy with six major dimensions – system quality, information quality, use, user satisfaction, individual impact, and organizational impact. Their study on IS success model was based on the review of 180 conceptual and empirical studies.

As the output of an information system or the message in a communication system, information can be measured at different levels, including the technical level, the semantic level, and the effectiveness level (Shannon and Weaver, 1949). For Shannon and Weaver (1949), these were defined as accuracy and efficiency of the system, the success of the information in conveying the intended meaning, and the effect of the information on the receiver, respectively. Based on this concept, DeLone and McLean argued that information flows through a series of states from its production through its use or consumption to its influence on individual and/or organizational performance. The six distinct dimensions of IS success developed by DeLone and McLean (1992) matching with Shannon and Weaver's (1949) three dimensions are: system quality at technical level; information quality at semantic level; and use, user satisfaction, individual impact, and organizational impact at effectiveness level.

The present study built, as an expansion of the general IS success model, an OSS EIS success model employing seven constructs: *Information Quality, OSS EIS Quality, Community Service Quality, OSS Use, User Satisfaction, Individual Net Benefit, and Organizational Net Benefit.*

2.5.1 SYSTEM QUALITY

System quality construct has been represented in some of prior research as ease of use to measure the quality of an information system itself. Some IS researchers have studied the processing system itself to evaluate the contribution of information systems to the organization. Rai et al. (2002) utilized user friendliness and ease of use as the two instruments to measure system quality. For his IS success study in the context of data warehouse, Shin (2003) included system throughput, ease of use, ability to locate data, access authorization, and data quality (currency, level of detail, accuracy, consistency). Wixom and Todd (2005) defined reliability, flexibility, integration, accessibility, and timeliness as the measures of system quality in their combined model of user satisfaction and technology acceptance.

Sabherwal et al. (2006) defined system quality as the quality of the system in terms of reliability, ease of use, and response time. Their work separated user-related constructs and context-related constructs from prior IS success models. They used systems quality as a construct representing IS success. Gable et al. (2003) used system quality as a construct of success for enterprise information systems. Sedera and Gable (2004) found nine validated items to measure system quality for enterprise system success. The nine items include: ease of use, ease of learning, user requirements, system fearues, system accuracy, flexibility, sophistication, integration, and customization.

2.5.2 INFORMATION QUALITY

Information quality is to measure outputs of an information system. Wixom and Todd (2005) developed an integrated research model based on two research stream, user satisfaction literature and technology acceptance literature. They defined completeness, accuracy, format, and currency as four information quality antecedents. Rai et al. (2002) developed seven items to measure information quality, which has the attributes of content, accuracy, and format required by the user. Shin (2003) investigated information quality dimension by measuring the utility (usefulness) of information acquired from a data warehouse. Some IS researchers have preferred to measure the quality of the information that the system produces, primarily in the form of reports. Gable et al. (2003) used information quality as an IS success factor of enterprise systems.

Ahituv (1980) developed five information characteristics: accuracy, timeliness, relevance, aggregation, and formatting. Swanson (1974) developed measurements, such as uniqueness, conciseness, clarity, and readability to measure IS appreciation among user managers. King and Epstein (1983) proposed multiple information attributes including sufficiency, understandability, freedom from bias, reliability, decision relevance, comparability, and quantitativeness to yield a composite measure of information value. Iivari and Koskela (1987) included three information quality constructs: informativeness, which consists of relevance, comprehensiveness, recentness, accuracy, and credibility; accessibility which consists of convenience, timeliness, and interpretability; and adaptability.

2.5.3 SERVICE QUALITY

Service quality is to measure the extent of service that IS users experience from communities. Communities, in our context of OSS EIS, include on-line communities or partners who provide OSS EIS and/or supports to organizations. Researchers who argue to include service quality as a measure of IS success apply the 22-item SERVQUAL measurement instrument. SERVQUAL measurement includes five dimensions: tangible, reliability, responsiveness, assurance, and empathy. Examples of the instruments are: “IS has up-to-date hardware and software” (tangible); “IS is dependable” (reliability); “IS employees give prompt service to users” (responsiveness); “IS employees have the knowledge to do their job well” (assurance); “IS has users’ best interests at heart” (empathy) (DeLone and McLean, 2003).

Parasuraman et al. (1988) originally developed the 22-item SERVQUAL instrument for assessing customer perceptions of service quality in service and retailing organizations. There were some controversies between Parasuraman et al.'s (1988) work and other studies regarding the discrepancy between expectations and perceptions (Cronin and Taylor, 1992; Teas, 1993) and difference score conceptualization (Brown et al., 1993). Asubonteng et al. (1996) compared Parasuraman et al.'s work (1988) with other studies in terms of the scale's psychometric properties. Lee et al. (2000) confirmed that perceived service quality is an antecedent of satisfaction.

Yang et al. (2004) claimed the difficulty of defining and interpreting the meaning of service quality in Web sites. Service quality dimensions differ according to the context. It is hard to develop a global measure of service quality for IS. DeLone and McLean (2003) defined service quality in e-commerce context as "the overall support delivered by the service provider, applies regardless of whether this support is delivered by the IS department, a new organizational unit, or outsourced to an Internet service provider (ISP). Its importance is most likely greater than previously since the users are now our customers and poor user support will translate into lost customers and lost sales (p.25)." Shin (2003) included user training as construct for service quality for a IS success model. Yang et al. (2005) validated five instruments to measure service quality on a Web portal. The instruments include: usability, usefulness of content, adequacy of information, accessibility, and interaction. Pitt et al. (1995) insisted to include service quality in assessment package of IS success.

2.5.4 SYSTEM USE

System use use is an indicator that shows the extent of OSS EIS use by individual users. Rai et al. (2002) measured 'utilization' for IS use through an instrument. Utilization is the degree to which the user is dependent on the IS for the execution of their tasks. Sabherwal et al. (2006) used system use as a construct to measure the individual's behavior of, or effort put into, using the system.

2.5.5 USER SATISFACTION

User satisfaction is to measure recipients' response to the use of the output of an information system. Sabherwal et al. (2006) used user satisfaction as a construct for IS. Chen et al. (2000) and Ginzberg (1981a, b) chose user satisfaction as his dependent variable. Some IS researchers have suggested user satisfaction as a success measure for their empirical IS research (Ein-Dor and Segev, 1978; Hamilton and Chervany, 1981). Rai et al. (2002) defined user satisfaction as perceptual measures of net benefits from IS use for their study in assessing the validity of IS success models.

2.5.6 INDIVIDUAL IMPACT

Individual impact is to measure the effect of information on the behavior of the recipient. Impact is probably the most difficult measure to define in a non-ambiguous fashion. It is closely related to performance, and so "improving my - or my department's - performance" is certainly evidence that the information system has had a positive impact. Sabherwal et al. (2006) defined individual impact as perceived usefulness in their work of

IS success on individual and organizational impact. Their definition of individual impact is the degree to which an individual believes that using the system enhances his or her productivity and job performance. IS success research on enterprise system (Gable et al., 2003; Sedera and Gable, 2004) defined individual impact as an IS success measure. Sedera and Gable (2004) measured individual impact for their enterprise systems success measurement model by using four items: learning, awareness/recall, decision effectiveness, and individual productivity.

2.5.7 ORGANIZATIONAL IMPACT

Organizational Impact is a construct intended to measure the effect of information on organizational performance. Gable et al. (2003) included enterprise system-related measures for their IS success model. They insisted that the measure of system quality for EIS must be the extent to which functionality and data have been integrated. The four measures they added were customization (system quality), increased capacity, e-government, and business process change. Sedra and Gable (2004) identified 8 items to measure organizational impact, including organizational costs, staff requirements, cost reduction, overall productivity, improved outcomes/outputs, increased capacity, e-Government, and business process change.

CHAPTER THREE

RESEARCH DESIGN AND METHODS

"In devising any methodological strategy, it is prudent to take into consideration the subjects' perceptions (Rosnow and Rosenthal 1996, p.5)."

This chapter outlines the research framework and methodology employed in this study. The research is based on a two-phase qualitative/quantitative mixed method as shown in Figure 1.2. The first phase of the study is a descriptive research employing a qualitative method, which is to describe what is happening and to map out a situation (Rosnow and Rosenthal, 1996). It investigates online OSS communities to identify the most downloaded OSS EIS modules. The second phase is considered a relational research design that seeks to understand how the variables are related. It extends the IS success model by including OSS and EIS properties. This section discusses the research model, hypotheses, variables, survey instrument, data sources, sample selection, and statistical techniques employed in the study.

3.1 PHASE ONE

This chapter describes a method to categorize OSS EIS projects into major EIS modules defined in Chapter 2.2 and Table 2.5. The study conducts content analysis, which has been widely used for Web based data analysis (Finney and Corbett, 2007). The five steps of content analysis suggested by McMillan (2000) are: formulate research questions/hypotheses, select samples, define categories, train coders/coding, and analyze/interpret data.

3.1.1 DATA SELECTION

Investigating the top 10 OSS communities as shown in Table 1.1 found EIS projects from only four communities: SourceForge.net, GitHub, Launchpad, and TuxFamily. As of March 2010, SourceForge.net, the largest on-line OSS community nurtures more than 3,300 enterprise software projects. The projects were first sorted by the number of downloads and projects that have user comments. The projects that do not have user comments were ignored since in the second phase of this study uses the constructs of user perspectives and the results from the two phases are compared. The descriptions of the most downloaded 1,199 projects were retrieved from SourceForge.net. Other communities either have a small number of EIS projects or are impossible to categorize projects. Five EIS projects from GitHub, 35 from Launchpad, and 1 from TuxFamily are added and a total of 1,240 OSS EIS projects are collected and analyzed.

3.1.2 UNITS OF CONTENT ANALYSIS

Two general types of units relevant to content analysis are study units and information units. Study units are the elements of content that are defined by the content analyst in the process of reducing and selecting the material to be studied. Information units are specifically related to the meaning and production of content, and selected by the content analyst, but they are defined independently of study, usually by the creator of the content.

Among the various types of units used in content analysis, the study adopts coding units and context units as study units that provide a sufficient condition in classifying OSS EIS projects into appropriate categories developed in Chapter 2.2 and Table 2.5. Coding units are the smallest segment of content counted and scored in the content analysis. The context unit is the body of material surrounding the coding unit.

The coding/recording unit of this study is the description of each project provided in on-line community Web sites. The description provides detailed information of projects, such as functions, update dates, compatibilities, etc. The context unit is of textual matter that sets limits on the information to be considered in the description of recording units. Krippendorf (2004) suggested that the best content analysis defines context units as large as meaningful (adding to their validity) and as small as feasible (adding to their reliability). Combining the two attributes, project name and description, help create a unique category for each project and, therefore, is used as the context unit.

3.1.3 SAMPLE

To have the effect of reducing the standard error and giving a more precise estimate of reliability, the suggested sample size is 20% or more of the population (Riffe et al., 2005). From the total of approximately 3,400 existing OSS EIS projects in the on-line OSS communities, the collected data size of 1,240 is well over the suggested sample size, 680. If the suggested sample size is simply followed, twenty nine categories in Table 2.5 is rather a large number and that may lead to too small a number of content in each category. Thus, the study used the 1,240 projects that are large enough to avoid this issue by having at least 40 contents in each category. The majority of the data for coding were collected from the on-line OSS communities by using a web crawler, Web Content Extractor, Version 4.0. An example of project title and description that were captured for the analysis is shown in Appendix D.

3.1.4 MODULES

For content analysis, the categories of the nominal scale must be independent, mutually exclusive, and exhaustive. The 29 EIS modules, identified based on literature review and shown in Table 2.5, provide the necessary conditions.

An N/A is added to the categories. The N/A category includes projects with a description written in a foreign language, no relation to any of EIS modules, insufficient information to categorize, ambiguous information, etc. EIS projects that have several functions are categorized into multiple modules.

3.1.5 INTER-CODER TRAINING AND RELIABILITY

Project descriptions are classified based on the coding scheme discussed in the previous section. The study follows the classification process used by Vessey et al. (2002). Having the same set of projects, the study could avoid the inter-coder reliability for changing content that McMillan (2000) referred. Knowing the sample size enabled the study to check the inter-coder reliability.

To achieve a minimum of 85% reliability agreement, the estimate agreement in the population (*P*) would be 90%. The confidence level of 95% with one-tailed *z* score, which is 1.64, yields the standard error (*SE*) of .03(.05 = 1.64 * *SE*). Using these numbers to achieve a minimum of 85% reliability agreement and assuming *P* equals 90% (5% above our minimum), the test sample size based on the formula that Riffe, Lacy, and Fico (2005) suggested is:

$$n = \frac{(N-1)(SE)^2 + PQN}{(N-1)(SE)^2 + PQ}$$

$$= \frac{(1239-1)(.03)^2 + .9 \times .1 \times 1239}{(1239-1)(.03)^2 + .9 \times .1}$$

$$= 93.457$$

in which
N = the population size (number of content units in the study)
P = the population level of agreement
Q = (1 – P)
n = the sample size for the reliability check

Only 94 projects out of the 1,240 projects are selected by using a random number generator. Random sampling is used for the inter-coder reliability test for two reasons: (1) it controls for the inevitable human biases in selection, and (2) it produces, with a known possibility of error, a sample that reflects the appropriate proportions of the characteristics of the overall population of content being studied.

The study employed three coders who are all doctoral students majoring in management. During the early stages of the classification process, the researchers coded 19 projects in each sitting. Each coding session was followed by a resolution session where disagreements in the coded data were resolved and recorded. After classifying and resolving the coding for the first 94 randomly selected projects, another set of 94 projects were randomly selected. The researchers coded 34 projects in each sitting followed by a resolution session again.

Inter-coder reliabilities were assessed for each of the categories using Cohen's kappa to determine whether the rules for coding were applied consistently across each coder. Cohen's kappa reliabilities for each pair of coders are listed in Table 3.1.

	Coder 1	Coder 2	Coder 3
Coder 1	--	.489	.478
Coder 2	--	--	.482
Coder 3	--	--	--

Table 3.1 Cohen's Kappa of Each Pair of Three Coders with p<.001

After the training sessions, coding process was implemented by a set of 100 projects at a time. The four sets of 100 projects showed similar distributions of OSS EIS modules. Because the projects were sorted by the number of downloads, the low-ranked projects were irrelevant projects or/and have ambiguous descriptions, which confused the coders. Since the accumulated inter-coder reliability was decreasing as more projects were coded, coding process was stopped. The average inter-coder reliability was .483 for the most downloaded 400 projects. According to Landis and Koch (1997), kappa values between .41 and .60 are regarded as "moderate." The reliability measures of agreement between three coders were quite satisfactory.

3.2 PHASE TWO

In this section, a design of the confirmatory study, based on prior IS success models and its extension, is discussed. Sub-sections include the details of the research design, research model, hypotheses, survey instrument, etc.

3.2.1 RESEARCH FRAMEWORK

To identify the factors that influence OSS EIS success, this study developed an OSS EIS success model based on a previous IS success model of DeLone and McLean (1992, 2003) and extends it by incorporating characteristics of OSS and EIS. DeLone and McLean proposed their original IS success model in 1992 and they presented a new framework in 2003.

In the first model, they identified six dimensions of success: system quality, information quality, use, user satisfaction, individual impact, and organizational impact, as discussed in Chapter Two. After a decade, this model was updated by adding another dimension, service quality. Pitt et al. (1995) suggested IS service quality as a factor of IS effectiveness in their assessment package.

Additionally, the new model simplified the “impacts” of individuals and the organization. Because of the ambiguity of the impact level suggested by many studies, such as work group impact, inter-organizational and industry impact, consumer impact, and societal impact, all the impact measures were grouped into a single category called “net benefits.” Recent works also show a wide range of contexts in the impact subject, such as organizational impact (Bayraktar et al., 2009; Hahn et al., 2009), cost impact (Borzekowski, 2009), operational impact (Kauremaa et al., 2009; Haigh and Griffiths, 2009), project management impact (Raymond and Bergeron, 2008), and human resource impact (Hussain et al., 2007).

Lee et al. (2009) investigated DeLone and McLean's (1992, 2003) model in OSS context. They dropped system quality from the model since their study focused on the success of OSS (e.g., Linux operating system), not on OSS-based application systems (e.g., Linux-based sales system). They claimed that OSS itself is not an application system and does not produce or process information as an output.

Based on observations of these previous studies, the present study used 7 dimensions to investigate the success factors of OSS EIS: information quality, OSS EIS quality, community service quality, OSS EIS use, user satisfaction, individual net benefits, and organizational net benefits as shown in Figure 1.1.

3.2.2 HYPOTHESES

Based on the reviews of IS success models in prior literature, the present research proposes the research model and hypotheses in this section. Ten hypotheses are proposed for this research as shown in Figures 3.1.

3.2.2.1 EFFECT OF INFORMATION QUALITY ON SYSTEM USE AND USER SATISFACTION

DeLone and McLean (1992) argued that the information quality and system quality singularly and jointly affect both use and user Satisfaction. Unlike other IS, such as operating systems that do not have outputs to users, EIS produce formal system outputs such as reports, documents, etc. To incorporate this EIS characteristic of the research, Information Quality must be measured and its relationship with system use (OSS EIS Use in this study) and User Satisfaction.

Rai et al. (2002) performed confirmatory factor analyses on DeLone and McLean's model (2003) and Seddon's model (1997). They found information quality has significant effects on both system use and user satisfaction in Seddon's model. Information quality has significant effects on system use in DeLone and McLean's model. Since these relationship may also be applicable within the OSS EIS context, following hypotheses are made:

H1. Information Quality has a direct positive effect on OSS Use.

H2. Information Quality has a direct positive effect on User Satisfaction.

3.2.2.2 EFFECT OF SYSTEM QUALITY ON SYSTEM USE AND USER SATISFACTION

Sabherwal et al. (2006) suggested that system quality has significant effects on user satisfaction. DeLone and McLean (2003) hypothesized that the system quality (OSS EIS Quality in this research) is positively related to IS use. The Technology Acceptance Model (TAM) and related empirical studies show that perceived ease of use and usefulness, the two key aspects of system quality, have significant effects on attitude toward using IS (Davis, 1989). Seddon and Kiew (1994) found the relationship between system quality and user satisfaction to be statistically significant.

Later, Rai et al. (2002) confirmed the significant effects of ease of use, which is equivalent to system quality, on user satisfaction by exploiting Seddon's (1997) model.

They also confirmed that ease of use has significant effects on user satisfaction in DeLone and McLean's (2003) model. Since these relationships may also be applicable within the OSS EIS context, following hypotheses are made:

H3. OSS EIS Quality has a direct positive effect on OSS EIS Use.

H4. OSS EIS Quality has a direct positive effect on User Satisfaction.

3.2.2.3 EFFECT OF SERVICE QUALITY ON SYSTEM USE AND USER SATISFACTION

Pitt et al. (1995) suggested that service quality (Community Service Quality in this study) influence IS use (OSS EIS Use in this study). DeLone and McLean (2003) also suggested that service quality is positively related to IS use. In many prior studies, service quality is regarded as an antecedent to satisfaction (Bitner et al., 1990; Lee and Yoo, 2000). Since these relationships may also be applicable within the OSS EIS context, following hypotheses are made:

H5. Community Service Quality has a direct positive effect on OSS EIS Use.

H6. Community Service Quality has a direct positive effect on User Satisfaction.

3.2.2.4 EFFECT OF USER SATISFACTION ON SYSTEM USE

The relationship between user satisfaction and system use are widely supported by prior studies (D'Ambra and Rice, 2001; Gelderman, 1998; Grover et al., 1998). An empirical study by Bolton and Lemon (1999) found that those users who are satisfied with an IS continue to use the IS. Since the relationship may also be applicable within the OSS EIS context, following hypothesis is made:

H7. User Satisfaction has a direct positive effect on OSS EIS Use.

3.2.2.5 EFFECT OF SYSTEM USE ON INDIVIDUAL NET BENEFIT

A number of previous studies support the positive relationship between system use and individual net benefit (Sabherwal et al., 2006; D'Ambra, 2001; Doll and Torkzadeh, 1998; Guimaraes and Igbaria, 1997; Grover et al., 1996; Hitt and Brynjolfsson, 1994; Clemons et al., 1993; Bailey and Pearson, 1983;). Srinivasan (1985) also found that the indicators of system use are significantly related to the problem solving capabilities of the user. Since this relationship may also be applicable within the OSS EIS context, following hypothesis is made:

H8. OSS EIS Use has a direct positive effect on Individual Net Benefit.

3.2.2.6 EFFECT OF USER SATISFACTION ON INDIVIDUAL NET BENEFIT

Lee et al. (2009) argued that the relationship between user satisfaction and individual net benefits can be explained by the affect-as-information model. According to the affect-as-information model, people rely on their actual feelings (satisfaction or emotional response) to form overall judgments (net benefits). This is because feelings are influential not just in determining valuable judgmental information, but also are regarded as representatives of the target. Gatian (1994) also supported this relationship, which can be applicable for the OSS EIS context.

Rai et al's (2002) confirmatory factor analyses on DeLone and McLean's (2003) and Seddon's (1997) IS success model revealed that user satisfaction has significant effects on perceived usefulness, which can be translated to individual impact. Since the relationship may also be applicable within the OSS EIS context, following hypothesis is made:

H9. User Satisfaction has a direct positive effect on Individual Net Benefits.

DeLone and McLean (2003) argued in their updated model that no system use is totally voluntary. At some level of organization, executives or managers required employees to use a certain type of information systems. Hence, the continued adoption and use of the system itself may not be voluntary. In the context of EIS of the present study, use of system has to be assumed as mandatory.

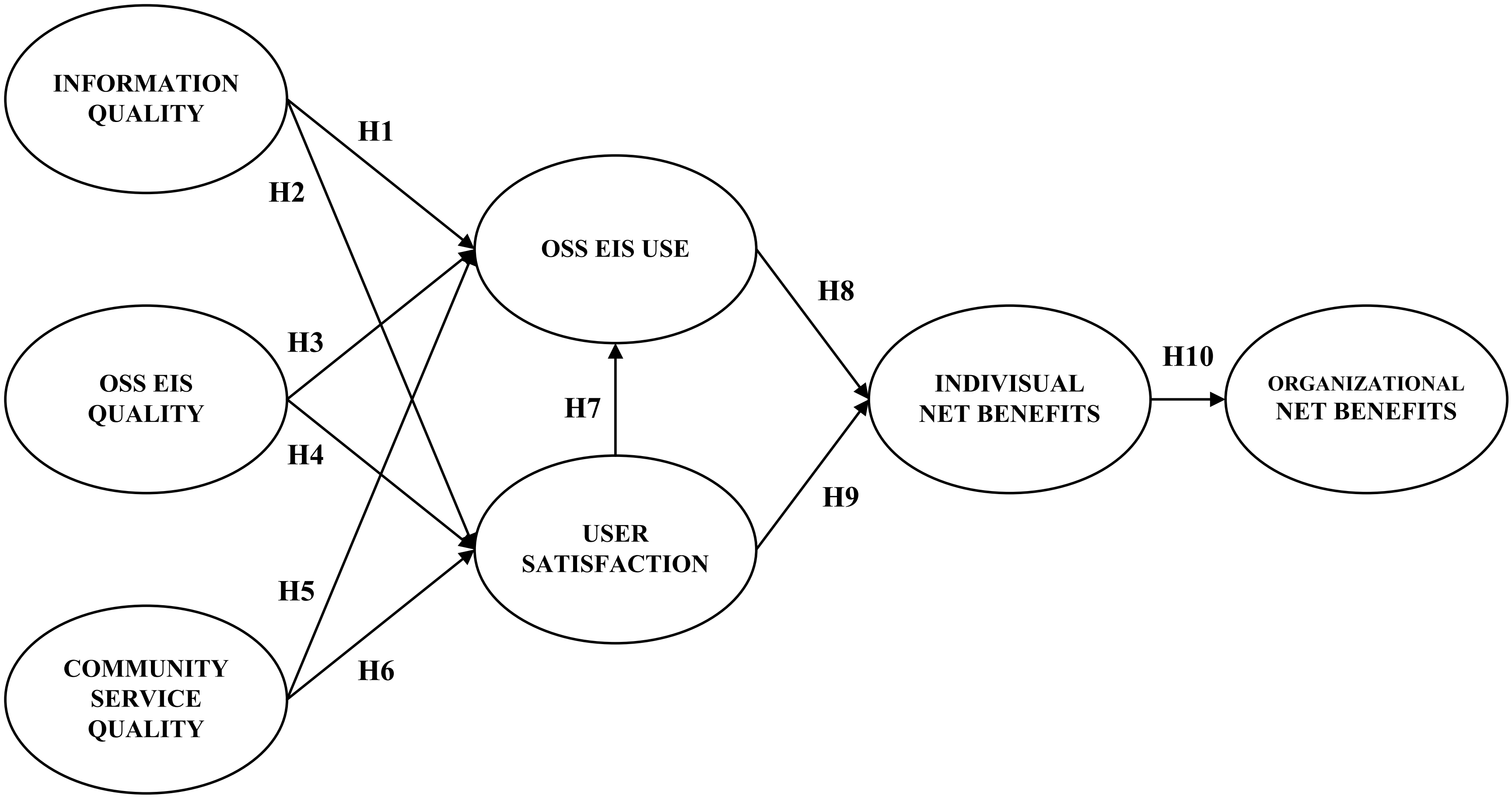
The study is interested in investigating the path where the effect of user satisfaction on individual net benefit is mediated by OSS EIS use. Direct effect, indirect effect, and total effect are calculated and compared.

3.2.2.7 EFFECT OF INDIVIDUAL NET BENEFIT ON ORGANIZATIONAL NET BENEFIT

DeLone and McLean (2003) argued that net benefits are measured in terms of job and decision-making performance. As the impact of IS evolves beyond the immediate user, prior studies suggested additional IS impact measures. The choice of where the impacts should be measured depends on the system or systems being evaluated and their purposes (DeLone and McLean, 2003). DeLone and McLean simplified their original IS success model by removing the organizational net benefits.

The present research separates organizational net benefits from individual net benefits to incorporating the characteristic of EIS that are utilized at the organizational level. The relationship between individual net benefit and organizational net benefit is supported by prior studies of Chan (2000) and Etezadi-Amoli and Farhoomand (1996), and it may also be applicable within the OSS EIS context. Hence, the study hypothesizes:

H10. Individual Net Benefit has a direct positive effect on Organizational Net Benefit.



<u>Figure 3.1 Research Model with Hypotheses</u>

3.2.3 MEASURES OF ENDOGENOUS VARIABLES

The model has four endogenous variables: *OSS EIS Use, User Satisfaction, Individual Net Benefits, and Organizational Net Benefits.* The study developed the survey instrument by employing existing validated instruments wherever possible.

OSS EIS Use is equivalent to the system use construct in the prior studies of IS success in general discussed in 2.5.4. *OSS EIS Use* is to measure the level of OSS EIS use by a user. Prior studies on IS success used system use as a construct in IS success models (Kim and Lee, 1986; Rai et al., 2002; Sabherwal et al., 2006; Lee et al., 2009). Seddon (1997) argued for the removal of the 'system use' construct in DeLone and McLean's first model because of its ambiguity. This issue was further investigated by later studies and considered unjustifiable, considering the nature of the construct of various research purposes. Lee et al. (2009) adopted the instruments for their study of OSS success from the work of Cheung et al. (2000). Measurement items for OSS EIS Use of this study were also adopted from Cheung et al. (2000)

User Satisfaction is a construct to measure users' feelings about OSS EIS and their response to the outputs of OSS EIS. User satisfaction has been employed as an IS success factor in prior studies of various contexts (Sabherwal et al., 2006; Chen et al., 2000; Rai et al., 2002; Shin, 2003). Bailey and Pearson (1983)'s study, which has been a foundation of many IS success research, developed 39 items to measure and analyze computer user satisfaction. Their study was based on a review of 22 studies of the computer/user interface. Many items they identified were related to the 80's electronic data processing system, called the EDP system. Computer systems have been changed during past decades in terms of architecture, hardware, software, network, and interface.

It may not be appropriate to use the same instruments for OSS EIS. For this reason the present research excluded all the items related to EDP from Bailey and Pearson's (1983) items, such as: organizational position of the EDP function and the hierarchical relationship of the EDP function to the overall organizational structure. Any items measured by the precedent constructs of the study, which are the exogenous variables, are also excluded from the present research.

Individual Net Benefit is to measure how OSS EIS has influenced users' individual capabilities and effectiveness on behalf of the organization. This construct is equivalent to individual impact described in 2.5.6. Some researchers (Gable et al., 2003; Sedera and Gable, 2004) used individual net benefit as success factor in IS success research on enterprise system. Sabherwal et al. (2006) measured perceived usefulness for individual impact in their work of IS success.

This construct was excluded from DeLone and McLean's (2003) updated IS success model due to its ambiguity as described in Chapter Two. However, the present research uses this construct because it concerns enterprise level software and, therefore, has to incorporate organizational characteristics. The present research adopts four items of Gable et al.'s measurements (2003) for Individual Net Benefit.

Organizational Net Benefit is a measure of the extent to which OSS EIS has promoted improvement in organizational results and capabilities. This construct is equivalent to organizational impact in traditional IS success models. Three items of organization-impact measurements developed by Gable et al. (2003) were adapted for Organizational Net Benefit in this study. Gable et al. (2003) proposed an IS impact measurement model that explains the stream of net benefits from an IS as perceived by key user groups. The model includes four dimensions in two halves. The “impact” half measures individual and organizational benefits/impacts; the other half, “quality”, uses system quality and information quality as proxies for probable future impacts. The present research used system quality (OSS EIS Quality) and information quality as exogenous variables, which are explained in the following section. The endogenous variables and the measurement methods are defined in Table 3.2.

3.2.4 MEASURES OF EXOGENOUS VARIBALBES

The model of this study has three exogenous variables: *Information Quality, OSS EIS Quality,* and *Community Service Quality*. The study developed the survey instrument for exogenous variables by adopting existing validated instruments wherever possible as well.

Information Quality is to measure the quality of OSS EIS outputs: namely, the quality of the information the system produces in reports and on-screen. Many recent studies indicated information quality as a success factor of IS (Rai et al., 2002; Shin, 2003; Gable et al., 2003; Wixom and Todd, 2005). Wixom and Todd (2005) defined completeness, accuracy, format, and currency as four information quality antecedents. Rai et al. (2002) measured information quality of IS by using seven items: accuracy, relevance, sufficiency, correctness, satisfaction, quality of output, and value of output. Shin (2003) investigated information quality dimension by measuring the utility (usefulness) of information acquired from a data warehouse. Some IS researchers have preferred to measure the quality of the information that the system produces, primarily in the form of reports.

Gable et al. (2003) used information quality as an IS success factor of enterprise systems. Bailey and Pearson (1983) identified 9 items to measure information quality: accuracy, precision, currency, timeliness, reliability, completeness, format, and relevance. King and Epstein (1983) also identified 9 similar items. Mahmood (1987) identified report accuracy and report timeliness as information quality measurements. Miller and Doyle (1987) found 4 items to measure information quality: completeness of information, accuracy of information, relevance of reports, and timeliness of report. Srinivasan (1985) identified report accuracy, report relevance, understandability, and report timeliness as measurements for information quality. Based on the literature, the present research adopts the three most frequently used items: timeliness, accuracy, and relevancy.

OSS EIS Quality is utilized to measure the performance of OSS EIS. This construct is equivalent to the system quality construct described in 2.5.1. Prior studies used system quality as a IS success factor (Rai et al., 2002; Shin, 2003; Gable et al., 2003; Sedera and Gable, 2004; Wixom and Todd, 2005; Sabherwal et al., 2006).

DeLone and McLean (2003) developed this construct to measure the quality of information system itself. It is based on Bailey and Pearson (1983)'s study that identified convenience of access (ease of use), flexibility of system, integration of systems, and response time. Wixom and Todd (2005) defined reliability, flexibility, integration, accessibility, and timeliness as the instruments to measure system quality. Rai et al. (2002) identified user friendliness and ease of use to measure system quality. Shin (2003) identified system throughput, ease of use, ability to locate data, access authorization, and data quality (currency, level of detail, accuracy, consistency) to measure system quality. Sabherwal et al. (2006) defined reliability, ease of use, and response time to measure system quality. Their work separated user-related constructs and context-related constructs from the prior IS success model. They used system quality as a construct representing IS success.

Gable et al. (2003) found 10 items of system quality measurement from prior studies and used system quality as a construct in a study of EIS success. Sedera and Gable's (2004) nine validated items to measure system quality for enterprise system success include: ease of use, ease of learning, user requirements, system fearues, system accuracy, flexibility, sophistication, integration, and customization. Belardo et al. (1982) identified reliability, response time, ease of use, and ease of learning; Srinivasan (1985) identified response time, reliability, and accessibility; Franz and Robey (1979) identified perceived usefulness of IS; Hiltz and Turoff (1981) and Goslar (1986) identified usefulness as measurements for system quality. Larcker and Lessig (1980) proved the validity and reliability of the perceived usefulness measure. The present research adopts the most frequently used items from the prior studies: response time, ease of use, and perceived usefulness.

Community Service Quality is to measure quality of community services that a user experiences. This construct is equivalent to service quality described in 2.5.3. OSS EIS communities include on-line communities or partners who provide OSS EIS and/or supports to organization. Shin (2003) defined user training to measure service quality. Yang et al. (2005) measured service quality by validating and using five validated instruments: usability, usefulness of content, adequacy of information, accessibility, and interaction.

The original model DeLone and McLean (1992) developed did not include service quality as an IS success factor. Pitt et al. (1995) argued that an IS success model should include a service component and they identified 5 items to measure service quality for IS effectiveness. Later, DeLone and McLean (2003) added service quality as a success measure in their IS success model. The present research adopts 5 measurement items from the studies done by Pitt et al. (1995) and DeLone and McLean (2003) based on SERVQUAL measurement instrument. Lee et al. (2009) adopted the same measurements for their study.

Since the present research concerns success factors of OSS EIS, it is necessary to incorporate OSS characteristics. OSS is developed in on-line communities by voluntary developers who may also provide maintenance and support, such as bug fixes. Because interactions between developers and users in on-line communities are observed, this study includes service quality as a construct for the OSS EIS success model. Questionnaire items suggested by DeLone and McLean (2003) are employed for *Community Service Quality*. The exogenous variables and the measurement methods are summarized in Table 3.3.

3.2.5 QUESTIONNAIRE DEVELOPMENT

As indicated in previous chapters, relatively few studies have empirically examined OSS from the users' perspective. However, previous studies that focus on user perception in the IS discipline provide a rich set of literature as a basis of questionnaire development for the present research. The measurement instrument, a survey of OSS EIS users, is developed by adapting existing validated instruments wherever possible.

The instrument used in this research consists of three parts. The first part collects basic demographic data on respondents and their organizations. The second part consists of general questions about OSS EIS that a user has experienced. In the second phase, users' actual use of OSS EIS in different fields is sought to compare the data with the results from the popularity analysis that is done in the first phase of the research. Part three of the survey is designed to identify a user's perspectives on OSS EIS. This part provides the data for confirmatory analysis of phase two of this study. The research model has seven constructs for which 30 questions are used based on previous studies.

Variable	Definition of Variable	Measurement Method
OSS EIS Use (OEU)	Level of OSS EIS use by a user.	1. I use OSS EIS very frequently (many times per month). 2. I use OSS EIS very intensively (many hours per day). 3. Overall, I use OSS EIS a lot.
User Satisfaction (USF)	Users' feelings about OSS EIS and response to the use of the output of OSS EIS.	1. The OSS EIS output information is complete. 2. I am satisfied with the material design of the layout and display of the output contents from OSS EIS. 3. I have strong feeling of control over OSS EIS. 4. Overall, I am satisfied with OSS EIS.
Individual Net Benefit (INB)	Influences of OSS EIS on user's individual capabilities and effectiveness on behalf of the organization.	1. I have learnt much through the presence of OSS EIS. 2. OSS EIS enhances my awareness and recall of job related information. 3. OSS EIS enhances my effectiveness in the job. 4. OSS EIS increases my productivity. 5. Overall, the impact of OSS EIS on me has been positive.
Organizational Net Benefit (ONB)	Improvements by OSS EIS in organizational results and capabilities.	1. OSS reduces cost. 2. OSS requires less number of staff then proprietary software does. 3. OSS improves outcomes/outputs. 4. Overall, OSS increases organizational productivity.

Table 3.2 Definition of Endogenous Variables and Measurement Methods

Variable	Definition of Variable	Measurement Method
Information Quality (IFQ)	Quality of OSS outputs: namely, the quality of the information the system produces in reports and on-screen.	1. Information from OSS is always timely. 2. Information from OSS is always accurate. 3. Information from OSS is always relevant to my tasks. 4. Overall, OSS information quality is satisfactory.
OSS EIS Quality (system quality) (OEQ)	Performance of OSS EIS.	1. OSS EIS response is always quick. 2. OSS EIS is easy to use. 3. OSS EIS has useful functions. 4. Overall, OSS EIS system quality is satisfactory.
Community Service Quality (CSQ)	Quality of community services that a user experiences.	1. OSS EIS community has up-to-date hardware and software. 2. OSS EIS community is dependable. 3. OSS EIS community gives prompt service to users. 4. OSS EIS community has the knowledge to do its job sell. 5. OSS EIS community has users' best interests at heart. 6. Overall, OSS EIS service quality is satisfactory.

Table 3.3 Definition of Exogenous Variables and Measurement Methods

3.2.6 DATA COLLECTION

The population of interest of this research is end users of OSS EIS. To recruit this population to collect an appropriate size of sample, the study first identified OSS EIS users from popular on-line OSS communities. The study found a total of 1,240 OSS EIS projects from on-line OSS communities by analyzing the title and description of OSS EIS projects. Approximately 1,200 OSS EIS projects were identified from SourceForge.net; 35 projects from Launchpad; 5 from GitHub; and 1 from TuxFamily.

Investigating users' comments on bulletin boards and blogs of the 1,240 OSS EIS projects yielded: 196 unique OSS EIS users from OSS EIS projects in SourceForge.net; 102 users from 35 projects in Launchpad.com; 2 users from 1 project in TuxFamily; and 10 users from 5 projects in GitHub. A total of 310 unique users and their e-mails were identified from on-line OSS communities.

The questionnaire was administered for a pretest by sending it to a subset of the 310 users. An invitation e-mail was sent to 103 users who participate in popular projects of SourceForge.net. Kaplowitz et al. (2004) observed a 20 percent response rate guideline for web surveys in their study. However, from 90 users except 13 bounced e-mails, a total of 9 valid responses was received, for a response rate of 8.73 percent. A soliciting letter for the survey was also posted in OSI (Open Source Initiative) website and only 3 valid responses were collected. On-line bulletin boards of OSS were randomly selected but no response was received.

Based on this dismal response rate experience, a survey agent who has over 25,000 panel members working in the software industry was solicited for the research cooperation. The agent contacted panels by e-mail and received a total of 157 responses. Seven incomplete responses were excluded from data analysis.

3.2.7 STATISTICAL TECHNIQUE

In the second phase of this research, a Structural Equation Model (SEM) was used. SEM is a statistical methodology that takes a confirmatory, rather than an exploratory, approach to data analysis (Byrne, 2010). Due to the confirmatory nature of present research, SEM is appropriate to test the causal relationships among the variables and test the hypotheses based on prior studies conducted in different context. Other advantages of SEM when compared to multiple regression include: 1) testing models with multiple dependent variables is conductible, 2) testing models with mediating variables is possible, and 3) analyzing multi-group samples is possible (Lee and Lim, 2009). Hence, SEM was chosen for modeling and investigating the relationships among variables because the present research involves analyses with multiple dependent variables, multiple groups of samples, and a mediating variable. To analyze the model of the research, AMOS 16.0 was used. The research model developed in AMOS is shown in Figure 3.3.

3.3 SUMMARY

The details of the research framework and methodology employed in this study were discussed in this chapter. For content analyses on on-line OSS communities, three coders were trained and achieved an acceptable rate of inter-coder reliability.

Based on the literature review discussed in 2.5, an OSS EIS success model was suggested. The model consists of: three exogenous variables - Information Quality, OSS EIS Quality, and Community Service Quality; four endogenous variables – OSS EIS Use, User Satisfaction, Individual Net Benefit, and Organizational Net Benefit. Eleven hypotheses were developed based on the paths between the variables.

Eleven constructs and their measurements were also discussed based on the prior studies. The details of data collection procedure of the study were presented. The issue with sample size is elaborated in 4.6 and 5.2.

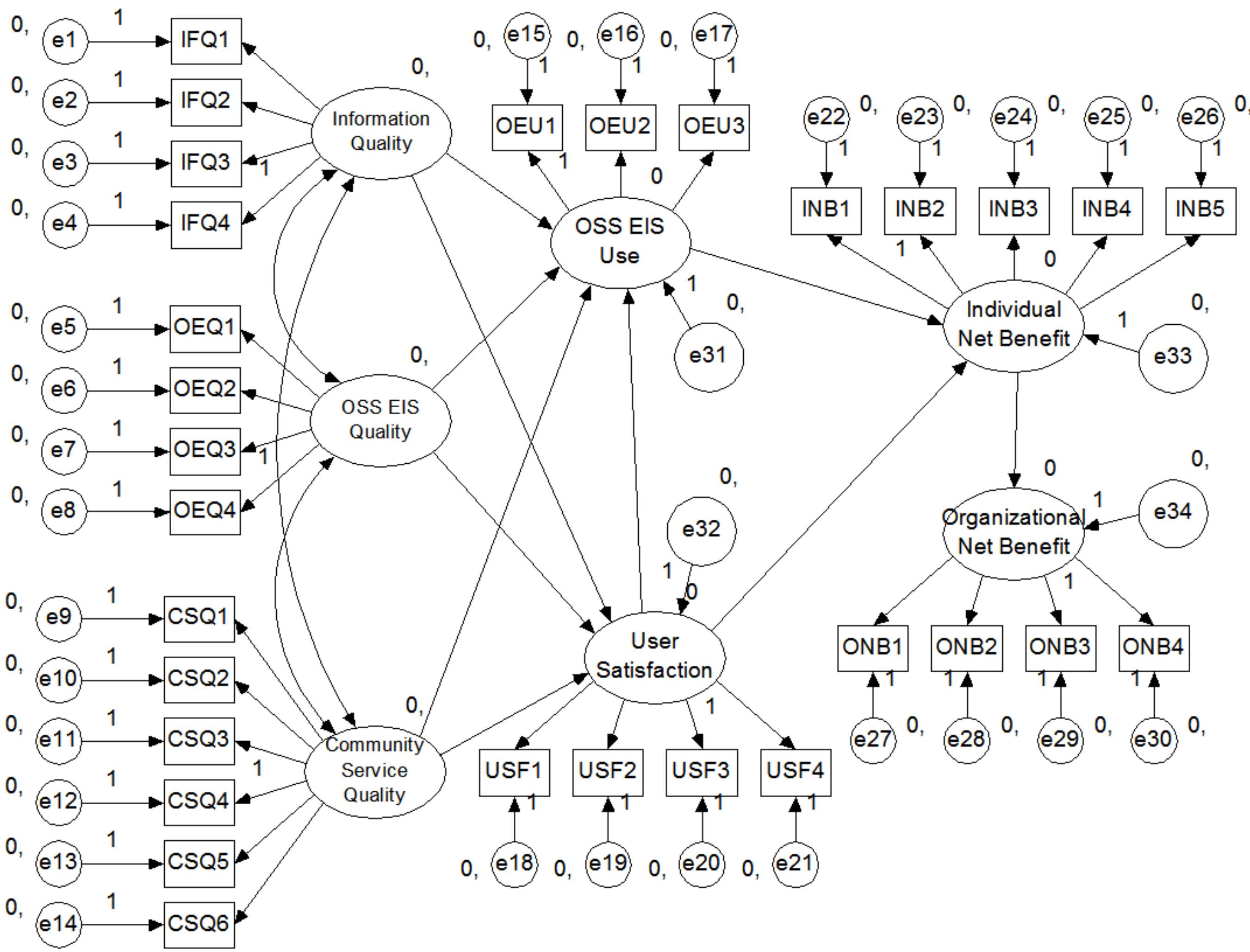


Figure 3.2 Research Model Drawn in AMOS

CHAPTER FOUR

RESULTS, ANALYSIS, AND DISCUSSION

"A mediator accounts for the relation between the predictor and the criterion (Baron and Kenny 1986, p.1176)."

Chapter Four presents the result of statistical analysis performed on the data collected from the survey. The analysis measures the relationships among the success factors of OSS EIS. This chapter is organized in four sections: (1) general characteristics of survey respondents, (2) general questions about OSS EIS, (3) validity and reliability of measurement tools, (4) validation of research model, and (5) discussion about the results of a content analysis and a confirmatory analysis on the proposed OSS EIS success model.

4.1 DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

The demographic characteristics of the 150 respondents within organizations using OSS EIS are as shown in Table 4.1. Respondents, mostly young professionals, aged 30~39 were highest (46.00%), followed by 19~29 (25.33%), 40~49 (20.00%), over 60 (4.67%), and 50~59 (4.00%).

For the industry of the respondents' organizations, IT/Communication was highest (34.00%), followed by Service (26.67%), Manufacturing (11.33%), Distribution (9.33%), and Financial (4.00%). For proprietary ERP implementation, as Park et al. (2002) showed, Manufacturing was highest (71.70%), which is quite different from the result of this study in which IT/communication and service take over 60%. For annual revenue of organization, less than 0.5M was highest (26.67%), followed by $1M ~ less than $10M (24.67%), $0.5M ~ $1.0M (19.33%), $10M ~ less than $50M (18.00%), $50M ~ less than $500M (7.33%), and over $500M (4.00%).

Category		Frequency	Percent
Gender	Male	78	52.00%
	Female	72	48.00%
Age	19~29	38	25.33%
	30~39	69	46.00%
	40~49	30	20.00%
	50~59	6	4.00%
	Over 60	7	4.67%
Industry list	IT/Communication	51	34.00%
	Service	40	26.67%
	Manufacturing	17	11.33%
	Distribution	14	9.33%
	Financial	6	4.00%
	Other	22	14.67%
Annual revenue	0 ~ $0.5 M	40	26.67%
	$0.5 M ~ Less than $1 M	29	19.33%
	$1 M ~ Less than $10 M	37	24.67%
	$10 M ~ Less than $50 M	27	18.00%
	$50 M ~ Less than $500 M	11	7.33%
	Over $500 M	6	4.00%
Number of employees	Less than 100	62	41.33%
	101~300	49	32.67%
	301~1,000	22	14.67%
	1,001~9,999	13	8.67%
	Over 10000	4	2.67%
Total		150	100.00%

Table 4.1 Demographic Characteristics

Lastly, for the question asking for the number of employees in the organization, less than 100 was highest (41.33%), followed by 101~300 (32.6 7%), 301~1,000 (14.67%), and 1,001~9,999 (8.67%), and over 10,000 (2.67%). The number of employees is the most common way of classifying organizations. Ghobadian and O'Regan (2000) suggested that firms employing fewer than 250 employees can be classified as SMBs. As shown in the survey results, about 74% of the respondents are within the firms employing less than 300 employees. This result confirms the results of Serrano and Sarriegi's work (2006) claiming that SMBs pursue to adopt OSS.

4.2 GENERAL CHARACTERISTICS OF OSS EIS

4.2.1 DURATION OF OSS EIS USE

The responses on the duration of OSS EIS use in organization are shown in Table 4.2. 1 year ~ 2 years was highest (34.00%), followed by 6 months ~ 1 year (28.00%), less than six months (15.33%), 2 ~ 5 years (14.00%), and more than 5 years (8.67%). The results indicate that most organizations are relatively new users of OSS EIS. Over 43% of the organizations have used OSS EIS less than 1 year.

Category	Frequency	Percent
Less than six months	23	15.33%
6 months ~ 1 year	42	28.00%
1 year ~ 2 years	51	34.00%
2 ~ 5 years	21	14.00%
More than 5 years	13	8.67%
Total	150	100.00%

Table 4.2 Duration of OSS EIS Use

4.2.2 OSS EIS MODULES IN USE

The responses on OSS EIS modules which respondents have experiences are as follows. For ERP, Financial and Accounting was experienced by 15.09% of respondents, followed by Order Entry (12.03%), Financial Control (11.32%), Production Planning (10.14%), Materials Management (9.91%), Purchasing (9.91%), Distribution/Logistics (9.43%), Personnel/Human Resources (7.08%), Asset Management (6.13%), Maintenance (5.19%), and R&D Management (3.77%).

This result is quite different from the findings of a prior study by Olson et al. (forthcoming in 2010). Olson et al., in their study about OSS ERP, insisted that the most downloaded OSS ERP modules were Maintenance, which were over 51% of 227 OSS ERP modules they found in SourceForege.net. However, when compared with proprietary ERP modules implemented in US manufacturing firms, the survey result follows very close patterns. Mabert et al. (2000) found that 91.50% of US manufacturing firms adopt proprietary Financial and Accounting module and other modules in a similar pattern to the survey results of the present study.

For CRM, Data Integration/Data Warehousing was highest (19.49%), followed by Knowledge Management (17.23%), Channel Management (14.97%), Sales (13.28%), Product Management (11.02%), Call Center/Help Desk (9.60%), Marketing (9.32%), and Field (5.08%). This result is closely consistent with the result of Olson et al.'s study (forthcoming in 2010).

Lastly, for SCM, Data Management was highest at 15.03%, followed by Make (13.99%), Delivery (13.73%), Decision Support (11.14%), Source (8.81%), Relationship Management (8.55%), Return (8.29%), and Performance Improvement (5.44%). The definition of the Data Management category that the present research adopted from McLaren and Vuong's work (2008) includes XML, RFID, and EDI. Hence, the reason Data Management is the highest might be due to the increasing use of RFID in supply chain. The summary of OSS EIS use is shown in Table 4.3.

4.2.3 CUSTOMIZATION OF OSS EIS

The responses on percentage of OSS EIS customization to fit organizational needs are shown in Table 4.4. About 35% of respondents had to customize 10% ~ 20% of the OSS EIS they adopted, 24.83% of respondents experienced 20%~50% of customization, and only 10% of respondents experienced more than 50% of customization.

Park et al. (2002) studied the proprietary ERP implementations of 106 Korean firms. They found that less than 21% ~ 50% of customization was highest at 56.4% of respondents, followed by less than 10% (22.1%), 11% ~ 20% (14.7%), and more than 50%

(7.4%). Approximately 36.8% of proprietary ERP implementations had less than 20% of customization and about 65% of OSS experienced less than 20% of customization. The comparison of these two results confirms Serrano and Sarriegi's (2006) study that one of the three reasons why OSS is advantageous to implement and maintain ERPs: an increased adaptability to match the business processes and local regulations.

4.2.4 CONFIGURATION OF OSS EIS

The responses pertaining to agreement/disagreement for OSS EIS configuration are shown in Table 4.5. The following responses were based on a 5 point scale of '1=Strongly Disagree, 3=Neither Agree nor Disagree, 5=Strongly Agree'. The average scale for the question 'OSS EIS was configured by experts' was 2.93, 'We have experienced system performance problems due to the customization of OSS EIS we adopted' was 2.82, 'We have experienced software upgrade problems due to the customization of OSS EIS we implemented' was 2.74, while 'System reengineering has taken placed as OSS EIS implementation proceeds' was 2.77 points. All 4 questions scored less than the average median score of 3.0.

Category	Module	Frequency	Percent
ERP	Financial & Accounting	64	15.09%
	Financial Control	48	11.32%
	Production Planning	43	10.14%
	Purchasing	42	9.91%
	Materials Management	42	9.91%
	Distribution/Logistics	40	9.43%
	Personnel/Human Resources	30	7.08%
	Asset Management	26	6.13%
	Maintenance	22	5.19%
	R&D Management	16	3.77%
	Total	424	100.00%
CRM	Data Integration/Data Warehousing	69	19.49%
	Knowledge Management	61	17.23%
	Channel Management	53	14.97%
	Sales	47	13.28%
	Product Management	39	11.02%
	Call Center/Help Desk	34	9.60%
	Marketing	33	9.32%
	Field	18	5.08%
	Total	354	100.00%
SCM	Data Management	58	15.03%
	Plan	58	15.03%
	Make	54	13.99%
	Delivery	53	13.73%
	Decision Support	43	11.14%
	Source	34	8.81%
	Relationship Management	33	8.55%
	Return	32	8.29%
	Performance Improvement	21	5.44%
	Total	386	100.00%

Table 4.3 OSS EIS Module Experience

Category	Frequency	Percent
Less than 5%	16	10.74%
5%~10%	29	19.46%
10%~20%	52	34.90%
20%~50%	37	24.83%
More than 50%	15	10.07%
Total	149	100.00%

Table 4.4 Percentage of OSS EIS Customized

4.2.5 IMPLEMENTATION OF OSS EIS

The responses to the question on the implementation of OSS EIS in the organization are as shown in Table 4.6. OSS EIS implementation by OSS EIS community was highest at 28.99%, followed by third party OSS EIS distributor (23.67%), consulting firm (18.84%), in-house implementation (15.94%), and proprietary vendor (12.56%).

Category	MEAN	S.D
OSS EIS was configured by experts	2.93	0.89
We have experienced system performance problems due to the customization of OSS EIS we adopted.	2.82	0.85
System reengineering has taken placed as OSS EIS implementation proceeds.	2.77	0.81
We have experienced software upgrade problems due to the customization of OSS EIS we implemented.	2.74	0.84

Table 4.5 OSS EIS Configuration

Category	Frequency	Percent
OSS EIS community	60	28.99%
3rd party OSS EIS distributor	49	23.67%
Consulting firm	39	18.84%
In-house implementation	33	15.94%
Proprietary vendor	26	12.56%
Total	207	100.00%

Table 4.6 Implementation of OSS EIS

4.2.6 TECHNICAL SUPPORT FOR OSS EIS

The responses to the question asking about providers of technical support for OSS EIS are as shown in Table 4.7. For the question, a 5-point Likert scale was used and users were allowed to make multiple selections. OSS EIS community was highest at 31.33%, followed by consulting firm (24.67%), third party OSS EIS distributor (22.67%), In-house support (12.67%), and proprietary vendor (8.67%). This pattern is consistent with the question on the implementation of OSS EIS. A comparison between the results from implementation and technical supports indicates OSS communities provide most implementation and technical supports.

Category	Frequency	Percent
OSS EIS community	47	31.33%
Consulting firm	37	24.67%
3rd party OSS EIS distributor	34	22.67%
In-house support	19	12.67%
Proprietary vendor	13	8.67%
Total	150	100.00%

Table 4.7 Provider of technical support for OSS EIS

4.2.7 VARIOUS T-TESTS

The study performed three t-tests on the survey results to draw valuable insights from the observations of actual OSS EIS users' characteristics. The t-tests were performed on the multiple independent groups: (1) respondents with the duration of OSS EIS use for less than 1 year (65 respondents) vs. equal to or more than one year (85 respondents); (2) respondents at companies with less than 100 employees (62 respondents) vs. companies with 100 or more employees (88 respondents).

4.2.7.1 MODULE FREQUENCIES

Some basic comparisons between two groups were performed before implementing t-tests. In terms of frequencies of OSS EIS module use, Table 4.8 shows the list of modules that had significant differences between the two groups. In majority of the cases, organizations with longer experiences with OSS EIS tend to adopt more modules. Interestingly, Return was the only module that was adopted more frequently by organizations with shorter durations of OSS EIS use.

Modules	Years	N	%	Sig.
HR	>= 1	16	2.26	.025*
	< 1	16	3.50	
Data Integration/ Data Warehousing	>= 1	48	6.79	.021*
	< 1	21	4.60	
Make	>= 1	27	3.82	.006**
	< 1	27	5.90	
Return	>= 1	13	1.84	.044*
	< 1	19	4.16	
Source	>= 1	27	3.82	.007**
	< 1	7	1.53	

* P<.05; **p<.01; ***p<.001

Table 4.8 Module Use Based on Duration of OSS EIS use

When compared by the number of employees, organizations with more employees adopted less OSS EIS modules than organizations with fewer employees. For some modules, the organization with fewer employees adopted more modules (Personnel/Human Resources and Marketing). The modules that had significant differences between groups are shown in Table 4.9.

Modules	Emp	N	%	Sig.
Data Integration/ Data Warehousing	>= 100	50	6.83	.004**
	< 100	19	4.40	
Marketing	>= 100	15	2.05	.040*
	< 100	18	4.17	
Delivery	>= 100	36	4.92	.039*
	< 100	17	3.94	
Return	>= 100	16	2.19	.031*
	< 100	16	3.70	

* P<.05; **p<.01; ***p<.001

Table 4.9 Module Use Based on Number of Employees

4.2.7.2 DIFFERENCES WITH DURATION OF OSS EIS USE

Almost every organization adopting an ERP system must modify vendor software to some degree (Olson, 2004). Customization of ERP systems is a parallel process with implementation. To fit organizational needs, implementation of enterprise systems involves intensive reengineering and customization of software. Arinze and Anandarajan (2003) stated ERP software requires extensive customization in order to roll out production systems. The findings of prior studies on proprietary ERP can be extended to EIS in general and compared with OSS EIS. An independent samples t-test was performed to compare the sub-sample of organizations that used OSS EIS for less than one year and the sub-sample of organizations that used OSS EIS for one year or longer in regard to the extent of OSS EIS customization to fit organizational needs. The result showed that the organizations with longer OSS EIS had more customization as shown in Table 4.10. Unlike proprietary EIS, of which customization starts in early stage of implementation, OSS EIS can be tried out for a certain period and then customized to fit organizational needs.

Question	<1 M (SD)	≥1 M (SD)	t	p
What percentage of OSS EIS had to be customized to fit your organization's need? 1: less than 5% 2: 5% ~ 10% 3: 10% ~ 20% 4: 20% ~ 50% 5: More than 50%	2.56 (1.271)	3.40 (.862)	4.544	.000

Table 4.10 Duration of Use Comparison for Customization

4.2.7.3 DIFFERENCES WITH NUMBER OF EMPLOYEES

An independent samples t-test was performed to compare the sub-sample of organizations with less than 100 employees and the sub-sample of organizations with 100 or more employees in regard to the extent of OSS EIS customization to fit organizational needs. The result showed that the organizations with more employees perform more customization of OSS EIS for organizational fit. Another t-test was performed to compare the same sub-samples in regard to the duration of OSS EIS use. The result showed that the organization with more employees used OSS EIS longer than organizations with fewer employees. The results summarized are in Table 4.11.

Question	<100 M (SD)	≥100 M (SD)	t	p
What percentage of OSS EIS had to be customized to fit your organization's need? 1: less than 5% 2: 5% ~ 10% 3: 10% ~ 20% 4: 20% ~ 50% 5: More than 50%	2.74 (1.267)	3.25 (.979)	2.660	.009
How long has your organization used OSS EIS? 1: Less than six months 2: 6 months ~ 1 year 3: 1 ~ 2 years 4: 2 ~ 5 years 5: More than 5 years	2.37 (1.244)	2.98 (1.005)	3.175	.002

Table 4.11 Number of Employee Comparisons for Customization/Duration of Use

4.3 MODEL ANALYSES

One of the advantages of SEM is that the statistical methodology can reflects measurement errors (Lee and Lim, 2009). Two types of measurement errors, random errors and systematic errors can be involved in survey research. The first type, random errors are statistical fluctuations in the measured data due to the accuracy limitations of the measurement instrument. Random errors tend to push measurements up and down around an exact value. Systematic errors (also called bias) are reproducible inaccuracies due to any problems that occur consistently in the same direction. It tends to push measurements in the same direction and causes the average or mean value to be too big or too small. Random errors are likely to cancel out, on the average, over repeated measurements. Systematic errors do not cancel out but affect all measurements in roughly the same way (Rosnow and Rosenthal, 1996).

Reliability is the consistency of a set of measurements. It is the degree to which a variable of concept is measured consistently. Validity is the degree to which the intended variables are actually measured. This study used composite reliability to measure the internal consistency and reliability of the 30 survey questionnaires in 7 variables. For validity test, discriminant validity was examined through confirmatory factor analysis.

4.3.1 ANALYSIS OF THE MEASUREMENT MODEL

This research utilized AMOS software (version 16.0). After setting all relationships between latent variables, the study analyzed the measurement model to confirm model fitness. AMOS 16.0 presents three types of fit indices: absolute fit indices, incremental fit indices, and parsimony fit indices. Absolute fit indices include χ^2, GFI, AGFI, RMR, RMSEA, and Normed χ^2. They compare the hypothesized model with no model at all. Incremental fit indices include CFI, NFI, and TLIP. These fit indices compare the research model with the null model to test the model fit. The null model is an independence model that assumes that there is no relationship among all the measurement variables.

Parsimony fit indices include PGFI, PNFI, PCFI, and ACI, which compare competing models. The next section gives brief descriptions on each fit index that was used in this research followed by a discussion of model fitness of the present research.

4.3.1.1 MODEL FIT INDICES

χ^2 (Chi-square) is an absolute fit index that represents how well the model reflects the data. If the value is large, the model is a poor fit to the data. The larger the sample size is, the larger is the value. Since it is very sensitive to the sample size and the number of measurement variables, Chi-square must be considered with other indices when determining model fitness (Lee and Lim, 2009). It is represented as CMIN in AMOS. The higher P (probability value) associated with χ^2 indicates a good fit of the model (Byrne, 2010).

GFI (Goodness-of-Fit Index) is a measure of the relative amount of variance and covariance. AGFI (Adjusted Goodness-of-Fit Index) differs from GFI only in the fact that it adjusts for the number of degrees of freedom in the specified model. Both GFI and AGFI are absolute indices and range from zero to 1.00, with values close to 1.0 being indicative of good fit (Byrne, 2010).

RMR (Root Mean Square Residual) is an absolute index and represents the average residual value derived from the fitting of the variance-covariance matrix for the hypothesized model to the variance-covariance matrix of the sample data (Byrne, 2010). The closer RMR is to zero, the better the model fit. A value less than .05 is widely considered good fit and below .08 is considered adequate fit.

RMSEA (Root Mean Square Error of Approximation) is an absolute fit index. Because Chi-square is too sensitive to sample size and the number of measurement variables, RMSEA can provide an acceptable value. RMSEA ranges between zero and 1.0, with values less than .1 being indicative of good fit (Lee and Lim, 2010).

CFI (Comparative Fit Index) is an incremental fit index. It compares the hypothesized model with null model. It ranges between zero and 1.0, with acceptable values larger than .90 (Lee and Lim, 2010).

NFI (Normed Fit Index) is also an incremental fit index. This fit index deal with Chi-square values of two models, hypothesized model and null model. It ranges between zero and 1.0, with acceptable values larger than .90 (Lee and Lim, 2010).

PGFI (Parsimony Goodness-of-Fit Index) is a parsimony index that ranges between zero and 1.0. It does not have any implications by itself and should be compared with other PGFIs of competing models. The model has higher value of PGFI has a better fitness (Lee and Lim, 2010). PNFI (Parsimony Normed Fit Index) is another parsimony index that is most widely applied parsimony index. It ranges between zero and .10 (Lee and Lim, 2010).

4.3.1.2 MODEL FITNESS OF MEASUREMENT MODEL

The results of fitness test are presented in Table 4.12. First, χ^2 value was 787.845 (df=384, p=.000), suggesting a good fitness of the model ((χ^2 /df) = 2.052 < 3) (Byrne, 2010). Most of other fit indices, such as RMSEA (.084), CFI (.865), GFI (.767), fell out of the acceptable levels. Thereby, it was recommended to investigate item factor loadings.

After investigating item factor loadings, one item, “Overall, the impact of OSS EIS on me has been positive” of Individual Net Benefit was deleted because the item factor loading was lower than .50. After removing the two items, the results of new fitness tests are presented in Table 4.13. Chi-square (χ^2) value was 520.634 (df=329, p=.000), suggesting a good fitness of the model ((χ^2 /df) = 1.582 < 3) (Byrne, 2010).

Most of other fit indices, such as RMSEA (.063), CFI (.929) except GFI (.814), are in the acceptable levels.

Fit Index		Measurement	Acceptance Criteria	Acceptance Level
Absolute Fit Measures	χ^2	787.845 (df=384, p=.000)	p>.05 or (χ^2 /df) <3 2.052	Accept
	RMSEA	.084	Under .08	Reject
	GFI	.767	Over .9	Reject
Incremental Fit Measures	CFI	.865	Over .9	Reject

Table 4.12 Measurement Model Fitness

Fit Index		Measurement	Acceptance Criteria	Acceptance Level
Absolute Fit Measures	χ^2	595.558 (df=356, p=.000)	p>.05 or (χ^2 /df) <3 1.582	Accept
	RMSEA	.063	Under .08	Accpet
	GFI	.814	Over .9	Reject
Incremental Fit Measures	CFI	.929	Over .9	Accept

Table 4.13 New Measurement Model Fitness

4.3.2 RELIABILITY AND VALIDITY TEST

Item factor loadings and squared multiple correlations from the confirmatory factor analysis completed on the data collected in OSS EIS user perception is shown in Table 4.14. To measure construct validity, factor analysis is employed. Because the present study is based on a strong theoretical and/or empirical foundation, confirmatory factor analysis (CFA) is a useful method for testing construct validity (Kline, 2004).

Testing of discriminant validity is conducted based on a standard where mean variance (AVE) of latent variables are over .5 (Fornell and Lacker, 1981). Discriminant validity was established using the procedures outlined by Fornell and Lacker (1981), Table 4.15 shows the correlations between the latent variables and the average variance extracted (AVE) of each construct is shown on the diagonal. Fornell and Lacker (1981) prescribe that the squared correlation between constructs must be less than the average variance extracted (AVE) of each underlying construct in order for the constructs to have discriminant validity. In this research, there was no case was the square of a correlation between constructs greater than average variance extracted of the constructs (see Table 4.15).

Fornell and Lacker (1981) also suggest that convergent validity exits when item factor loadings are greater than .5 and item squared multiple correlations are greater than .5. In this study, one item ("Overall, the impact of OSS EIS on me has been positive" of Individual Net Benefit) were deleted because item factor loading was lower than .50. After two items deleted, a confirmatory factor model was tested. The resulting statistics was strong evidence of both discriminant (see Table 4.14) and convergent (see Table 4.15) validity.

Constructs	Variables	Factor-loading	SMC	C.R.
Information Quality	Information from OSS EIS is always timely	.571	.326	0.903
	Information from OSS EIS is always accurate	.833	.695	
	Information from OSS EIS is always relevant to my tasks	.698	.487	
	Overall, OSS EIS information quality is satisfactory	.825	.680	
OSS EIS Quality	OSS EIS response is always quick	.610	.372	0.893
	OSS EIS is easy to use	.638	.408	
	OSS EIS has useful functions	.809	.654	
	Overall, OSS EIS system quality is satisfactory	.849	.721	
Community Service Quality	OSS EIS community has up-to-date hardware and software	.713	.508	0.924
	OSS EIS community is dependable	.811	.657	
	OSS EIS community gives prompt service to users	.782	.612	
	OSS EIS community has the knowledge to do its job sell	.733	.537	
	OSS EIS community has users' best interests at heart	.809	.655	
	Overall, OSS EIS service quality is satisfactory	.811	.657	
OSS EIS Use	I use OSS EIS very frequently (many times per month)	.712	.506	0.850
	I use OSS EIS very intensively (many hours per day)	.852	.726	
	Overall, I use OSS EIS a lot	.784	.615	
User Satisfaction	The output information of OSS EIS is complete	.774	.599	0.838
	I am satisfied with the material design of the layout and display of the output contents from OSS EIS	.849	.721	
	I have strong feeling of control over OSS	.837	.700	
	Overall, I am satisfied with OSS	.873	.762	
Individual Net Benefits	I have learnt much through the presence of OSS EIS	.845	.714	0.909
	OSS EIS enhances my awareness and recall of job related information	.855	.731	
	OSS EIS enhances my effectiveness in the job	.805	.648	
	OSS EIS increases my productivity	.781	.610	
	Overall, the impact of OSS EIS on me has been positive	**Deleted**	**Deleted**	
Organizati-onal Net Benefits	OSS EIS reduces cost	.791	626	0.929
	OSS EIS requires less number of staff then proprietary software does	.800	640	
	OSS EIS improves outcomes/outputs	.893	.797	
	Overall, OSS EIS increases organizational productivity	.896	.802	

Table 4.14 Items, Factor-loadings, and Construct Reliability

		1	2	3	4	5	6	7
1	Information Quality	.704						
2	OSS EIS Quality	.066564	.681					
3	Community Service Quality	.829921	.024336	.670				
4	OSS EIS Use	.613089	.027556	.646416	.655			
5	User Satisfaction	.075076	.142129	.034596	.051076	.705		
6	Individual Net Benefit	.021316	.2304	.011025	.008464	.540225	.713	
7	Organizational Net Benefit	.156025	.034225	.101124	.117649	.128881	.0625	.768

Table 4.15 Means (Standard Deviation) and Correlation Matrix

4.4 ANALYSIS OF STRUCTURAL MODEL

4.4.1 MODEL FITNESS OF STRUCTURAL (FULL) MODEL

The results of fitness test are presented in Table 4.16. First, χ^2 value was 629.077 (df=364, p=.000), suggesting a good fitness of the model ((χ^2 /df) = 1.728 < 3) (Byrne, 2010). Other fit indices, such as RMSEA (.070) and GFI (.658) except CFI (.906) are within the acceptable levels. The adequacy of the structural equation models was evaluated on the criteria of overall fit with the data.

Fit Index		Measurement	Acceptance Criteria	Acceptance Level
Absolute Fit Measures	χ^2	629.077 (df=364, p=.000)	p>.05 or (χ^2 /df) <3 1.728	Accept
	RMSEA	.070	Under .08	Accept
	GFI	.658	Over .9	Reject
Incremental Fit Measures	CFI	.906	Over .9	Accept

Table 4.16 Overall Model Fitness

4.4.2 HYPOTHESES TESTING

Path coefficients between latent variables and path coefficients between latent variables and measurement variables were measured to validate their significance levels. The results of such analysis showed the OSS EIS Quality → User Satisfaction, Community Service Quality → OSS EIS Use, User Satisfaction → Individual Net

Benefit, Individual Net Benefit → Organizational Net Benefit path to be statistically significant ($p<.05$), while the Community Service Quality → User Satisfaction, Information Quality → OSS EIS Use, User Satisfaction → OSS EIS Use, OSS EIS Quality → OSS EIS Use, OSS EIS Use → Individual Net Benefit paths were not statistically significant ($p>.05$). An organization of various paths focusing on the major variables of interest within the study is shown in Tables 4.17.

4.4.2.1 EFFECTS ON OSS EIS USE

H1. Information Quality has a direct positive effect on OSS EIS Use.

H3. OSS EIS Quality has a direct positive effect on OSS EIS Use.

H5. Community Service Quality has a direct positive effect on OSS EIS Use.

H7. User Satisfaction has a direct positive effect on OSS EIS Use.

Paths 1, 3, 5, and 7 are shown to be paths where Information Quality, OSS EIS Quality, Community Service Quality, User Satisfaction have direct effects on OSS EIS Use. While the direct effect of Information Quality on OSS EIS Use was shown to be a positive (+) effect of .240, it was not a statistically significant result ($p=.279$). While the direct effect of OSS EIS Quality on OSS EIS Use was shown to be a negative (-) effect of -.018, it was not statistically significant ($p=.815$). The direct effect of Community Service Quality on OSS EIS Use was shown to be a positive (+) effect of .490 and was shown to be a statistically significant result ($p=.038$). While the direct effect of User Satisfaction on OSS EIS Use was shown to be a positive (+) effect of .038, it was not statistically significant ($p=.492$).

			Estimate	S.E.	C.R.	P
User_Satisfaction	<--	Information_Quality	.435	.385	1.131	.258
User_Satisfaction	<--	OSS EIS_Quality	.451	.132	3.419	***
User_Satisfaction	<--	Community_Service_Quality	-.264	.404	-.655	.513
OSS EIS_Use	<--	OSS EIS_Quality	-.018	.076	-.234	.815
OSS EIS_Use	<--	Community_Service_Quality	.490	.236	2.077	.038
OSS EIS_Use	<--	Information_Quality	.240	.222	1.082	.279
OSS EIS_Use	<--	User_Satisfaction	.038	.055	.687	.492
Individual_Net Benefit	<--	OSS EIS_Use	-.078	.087	-.896	.370
Individual_Net Benefit	<--	User_Satisfaction	.682	.079	8.662	***
Organizational_Net Benefit	<--	Individual_Net Benefit	.289	.094	3.082	.002
OEQ4	<--	OSS EIS_Quality	1.000			
OEQ3	<--	OSS EIS_Quality	.994	.101	9.829	***
OEQ2	<--	OSS EIS_Quality	.772	.098	7.876	***
OEQ1	<--	OSS EIS_Quality	.650	.087	7.447	***
CSQ4	<--	Community_Service_Quality	1.000			
CSQ3	<--	Community_Service_Quality	.961	.101	9.538	***
CSQ2	<--	Community_Service_Quality	1.084	.110	9.900	***
CSQ1	<--	Community_Service_Quality	.799	.093	8.629	***
IFQ4	<--	Information_Quality	1.000			
IFQ3	<--	Information_Quality	.889	.097	9.160	***
IFQ2	<--	Information_Quality	.939	.081	11.616	***
IFQ1	<--	Information_Quality	.739	.100	7.383	***
CSQ5	<--	Community_Service_Quality	1.085	.110	9.905	***
CSQ6	<--	Community_Service_Quality	1.104	.111	9.909	***
OEU1	<--	OSS EIS_Use	1.000			
OEU2	<--	OSS EIS_Use	1.338	.146	9.173	***
OEU3	<--	OSS EIS_Use	1.211	.139	8.688	***
USF3	<--	User_Satisfaction	1.000			
USF2	<--	User_Satisfaction	1.014	.081	12.508	***
USF1	<--	User_Satisfaction	.831	.077	10.763	***
ONB3	<--	Organizational_Net Benefit	1.000			
ONB2	<--	Organizational_Net Benefit	.889	.071	12.552	***
ONB1	<--	Organizational_Net Benefit	.832	.068	12.300	***
INB1	<--	Individual_Net Benefit	1.000			
INB2	<--	Individual_Net Benefit	1.112	.089	12.433	***
INB3	<--	Individual_Net Benefit	1.038	.089	11.611	***
INB4	<--	Individual_Net Benefit	.859	.079	10.911	***
ONB4	<--	Organizational_Net Benefit	1.023	.067	15.193	***
USF4	<--	User_Satisfaction	1.050	.080	13.107	***

Table 4.17 Path Coefficient and Significance Test of Structural Model

4.4.2.2 EFFECTS ON USER SATISFACTION

H2. Information Quality has a direct effect on User Satisfaction.

H4. OSS EIS Quality has a direct effect on User Satisfaction.

H6. Community Service Quality has a direct effect on User Satisfaction.

Paths 2, 4, and 6 are shown to be paths where Information Quality, OSS EIS Quality, Community Service Quality have direct effects on User Satisfaction. While the direct effect of Information Quality on User Satisfaction was positive (+) (.435), it was not shown to be statistically significant (p=.258). The direct effect of OSS EIS Quality on User Satisfaction was positive (+) (.451) and was shown to be statistically significant (p=.000). While the direct effect of Community Service Quality on User Satisfaction was negative (-) (-.264), it was not statistically significant (p=.513).

4.4.2.3 EFFECTS ON INDIVIDUAL NET BENEFIT

H8. OSS EIS Use has a direct positive effect on Individual Net Benefit.

H9. User Satisfaction has a direct positive effect on Individual Net Benefit.

Paths 8 and 9 are shown to be paths where User Satisfaction has a direct effect on Individual Net Benefit. While the direct effect of OSS EIS Use on Individual Net Benefit was negative (-) (-.078), it was not statistically significant (p=.370). The direct effect of User Satisfaction on Individual Net Benefit was positive (+) (.682) and was shown to be a statistically significant (p=.000).

4.4.2.4 EFFECTS ON ORGANIZATIONAL NET BENEFIT

H10. Individual Net Benefit has a direct effect on Organizational Net Benefit.

Path 10 is shown to be a path where Individual Net Benefit has a direct effect on Organizational Net Benefit. The direct effect of Individual Net Benefit on Organizational Net Benefit was shown to be a positive (+) effect of .289 and was shown to be a statistically significant result (p=.002). The results of hypotheses testing are summarized in Table 4.18.

Research Hypothesis	Hypothesis	Use
H1	Information Quality has a direct effect on OSS EIS Use.	Not Supported
H2	OSS EIS Quality has a direct effect on OSS EIS Use	Not Supported
H3	Community Service Quality has a direct effect on OSS EIS Use.	**SUPPORTED**
H4	User Satisfaction has a direct effect on OSS EIS Use.	Not Supported
H5	Information Quality has a direct effect on User Satisfaction.	Not Supported
H6	OSS EIS Quality has a direct effect on User Satisfaction.	**SUPPORTED**
H7	Community Service Quality has a direct effect on User Satisfaction.	Not Supported
H8	OSS EIS Use has a direct effect on Individual Net Benefit.	Not Supported
H9	User Satisfaction has a direct effect on Individual Net Benefit.	**SUPPORTED**
H10	Individual Net Benefit has a direct effect on Organizational Net Benefit.	**SUPPORTED**

Table 4.18 A Summary of Path Analysis Results

4.5 DISCUSSION

4.5.1 COMPARISON ON TWO RESULTS

As discussed in 3.1.5, due to the nature of sample, 400 most frequently downloaded OSS EIS projects were analyzed. The coders identified 273 distinguishable OSS EIS projects that consist of 126 (46.15 %) CRM, 94 (34.43%) ERP, and 53 (19.41%) SCM related projects. One hundred twenty seven projects were classified as N/A because the description of the projects were ambiguous, written in foreign languages, or not agreeable among coders.

ERP		CRM		SCM	
Production Planning	25	Data Integration/Data Warehousing	38	Decision Support	37
Financial & Accounting	20	Knowledge Management	34	Data Management	13
Personnel/HR	12	Call Center/Help Desk	11	Make	11
Materials Management	3	Channel Management	8	Plan	9
Order Entry	6	Sales	8	Delivery	3
Distribution/Logistics	5	Marketing	4	Return	0
Purchasing	4	Field	1	Source	1
Financial Control	4	Product Management	0	Relationship Management	0
Asset Management	4			Performance Improvement	0
Maintenance	2				
Quality Management	1				
R&D Management	1				
Total	87	Total	104	Total	74

Table 4.19 OSS EIS Modules Developed in On-Line Communities

The number of CRM projects was unexpectedly high as shown in Table 4.19. This was because: (1) Data Integration and Warehousing is one of the most frequently downloaded OSS EIS modules and (2) the taxonomy the present study used to classify OSS EIS for both content analysis and survey includes Data Integration and Warehousing under CRM class.

In terms of the modules downloaded, the results showed the similar pattern to the survey results. Among the ERP modules, Production Planning (25) was most frequently downloaded, followed by Financial & Accounting (20) and Personnel/Human Resources (12). For CRM modules, Data Integration/Data Warehousing (38) was most frequently downloaded, followed by Knowledge Management (34) and Call Center/Help Desk (11). For SCM modules, Decision Support was highest at 37, followed by Data Management (13) and Make (11). A comparison of the two results from the survey and the content analysis is shown in Table 4.20.

Although the study used the same taxonomy to classify OSS EIS modules for both survey and content analysis for consistency, some parts of the two results are quite different. Specifically, the top 8 modules of ERP are quite differently ranked. This may be explained by the coding processes that the study performed. In the training sessions, the coders agreed to classify the ERP projects related to project management into Production Management and the large number of occurrences of project management may help put the module in the highest rank. However, majority of CRM and SCM modules showed very similar patterns in both classifications except the Decision Support module of SCM.

In the training sessions, coders agreed to classify OLAP (On-Line Analytical Processing), which is a data analysis tool providing multiple perspectives (Laudon and Laoudon, 2009), into the Decision Support module instead of Data Integration/Data Warehousing. The comparison showed that the comprehensive classification utilized in this research needs more clear definition for certain modules, such as Production Planning, Data Integration/Data Warehousing, and Decision Support.

4.5.2 RESULTS OF STATISTICAL ANALYSIS

Among the ten hypotheses, only four hypotheses were supported by statistical analyses employed in the present research. Following sections include the details of hypotheses analysis.

4.5.2.1 OSS EIS USE CONSTRUCT

Prior studies about IS success have frequently defined information quality, system quality (OSS EIS Quality in this study), service quality (Community Service Quality), and user satisfaction as precedents of system use (OSS EIS Use) (DeLone and McLean, 1992; Seddon and Kiew, 1994; Pitt et al., 1995; Seddon, 1997; Rai et al., 2002; Sabherwal et al. 2006). However, the results of the study show that information quality, OSS EIS Quality, and User Satisfaction have no effect on OSS EIS Use. Only Community Service Quality has a direct positive effect on OSS EIS Use.

	Rank	Survey	Downloaded
ERP	1	Financial & Accounting	Production Planning
	2	Order Entry	Financial & Accounting
	3	Financial Control	Personnel/ Human Resources
	4	Production Planning	Materials Management
	5	Materials Management	Order Entry
	6	Purchasing	Distribution/Logistics
	7	Distribution/Logistics	Purchasing
	8	Personnel/Human Resources	Financial Control
	9	Asset Management	Asset Management
	10	Maintenance	Maintenance
	11	R&D Management	Quality Management
	12	Quality Management	R&D Management
CRM	1	Data Integration/Data Warehousing	Data Integration/Data Warehousing
	2	Knowledge Management	Knowledge Management
	3	Channel Management	Call Center/Help Desk
	4	Sales	Channel Management
	5	Product Management	Sales
	6	Call Center/Help Desk	Marketing
	7	Marketing	Field
	8	Field	Product Management
SCM	1	Data Management	Decision Support
	2	Plan	Data Management
	3	Make	Make
	4	Delivery	Plan
	5	Decision Support	Delivery
	6	Source	Return
	7	Relationship Management	Source
	8	Return	Relationship Management
	9	Performance Improvement	Performance Improvement

Table 4.20 A Comparison of Survey and Content Analysis

As discussed in 3.2.2.6, this result can be explained by the 'mandatory' issue with system use argued by DeLone and McLean (2003). Unlike other software, EIS are usually the only software package available in an organization for planned tasks. Once a certain type of EIS is implemented, system use is required across the organization. Use of EIS must be continued and cannot be voluntary by individual users.

As prior studies (Pitt et al., 1995; Shin, 2003; Yang et al., 2004) pointed out, the present study employed Community Service Quality as a precedent construct of OSS EIS use and the result shows it has a positive effect on OSS EIS. Upon reviewing the results, the only precedent of OSS EIS Use is Community Service Quality. In previous sections, it has been assumed that the OSS EIS use is mandatory. However, users can voluntarily use OSS EIS for a test drive before an actual implementation. In such a situation, the extent of Community Service Quality can be used as a decision factor of selecting an appropriate EIS for the organization's needs.

System use (OSS EIS Use) itself also has frequently been employed as a success factor effecting individual impact (Individual Net Benefit) in prior studies (Bailey and Pearson, 1983; Srinivasan, 1985; Clemons et al., 1993; Hitt and Brynjolfsson, 1994; Grover et al., 1996; Guimaraes and Igbaria, 1997; Doll and Torkzadeh, 1998; D'Ambra, 2001; Sabherwal et al., 2006). However, the results of the present research do not support the proposition. This is, again, can be explained by the 'mandatory' issue. If it is required to use OSS EIS, OSS EIS Use cannot be a precedent of Individual Net Benefit.

As discussed earlier, Seddon (1997) argued for the removal of the system use construct from DeLone and McLean's first model because of its ambiguity. The ambiguity issue was further investigated by later studies and considered unjustifiable because of the nature of the construct in various research purposes. Based on the prior studies on this issue, the context of OSS EIS, and the results from the analysis, the present study suggests an OSS EIS success model without the EIS OSS Use construct.

4.5.2.2 OTHER CONSTRUCTS

System quality (OSS EIS Quality) have direct positive effects on user satisfaction as described by the hypotheses developed based on prior studies (Seddon, 1997; Rai et al., 2002; McLean, 2003). However, unlike Lee et al.'s (2009) OSS success model, the present research found no significant direct positive effects of Community Service Quality on user satisfaction. This may be explained by DeLone and McLean's (2003) arguments that the role of quality determinants varies from context to context. Lee et al.'s (2009) study, about OSS in non-enterprise systems, found significant effects of community service quality on user satisfaction. Unlike desktop software, users of enterprise software, typically follow predefined routines to receive desired outputs from IS. Similarly, when users experience technical difficulties, they follow formal processes of problem solving through the organization. Hence, the quality of services from communities to resolve issues may not be directly transferred to end users. Instead, users may receive indirect effect of the service quality. Therefore, Community Service Quality may have no direct effects on User Satisfaction in the OSS EIS context.

The hypothesis on the effect of user satisfaction on individual impact (Individual Net Benefit) was supported as prior studies have found (Gatian, 1994; Rai et al, 2002; DeLone and McLean, 2003; Lee et al., 2009).

A direct positive effect of individual impact (Individual Net Benefit) on organizational impact (Organizational Net Benefit) was hypothesized and the result of analysis supported it. Lastly, the study performed the mediation analysis for system use (OSS EIS Use) between user satisfaction (User Satisfaction) and individual impact (Individual Net Benefits). The result showed a direct positive effect of user satisfaction (User Satisfaction) on individual impact (Individual Net Benefit) but the path was not mediated by system use (OSS EIS Use). User Satisfaction has a direct positive effect on Individual Net Benefit.

4.6 SUMMARY OF ANALYSES

In the first phase of the study, a content analysis was done on the on-going OSS EIS projects in most OSS on-line communities. The results of content analysis by three coders were discussed by various comparisons with the survey results in 4.5.1. In the second phase of the study, a survey on OSS EIS users was conducted. Then, a confirmatory analysis on the IS success model suggested by the present study was performed. The survey results confirmed prior studies' claim that OSS EIS enable SMBs to implement EIS at a minimal cost (Sudzina, 2008; Serrano and Sarriegi, 2006). Approximately 74% of the respondents were within the firms employing less than 300 employees, which can be classified as SMBs as suggested by Ghobadian and O'Regan (2000).

The questions about the use of OSS EIS modules revealed an interesting result. Especially for ERP modules, Financial and Accounting was the most widely experienced OSS module, followed by Order Entry, Financial Control, Production Planning, Materials

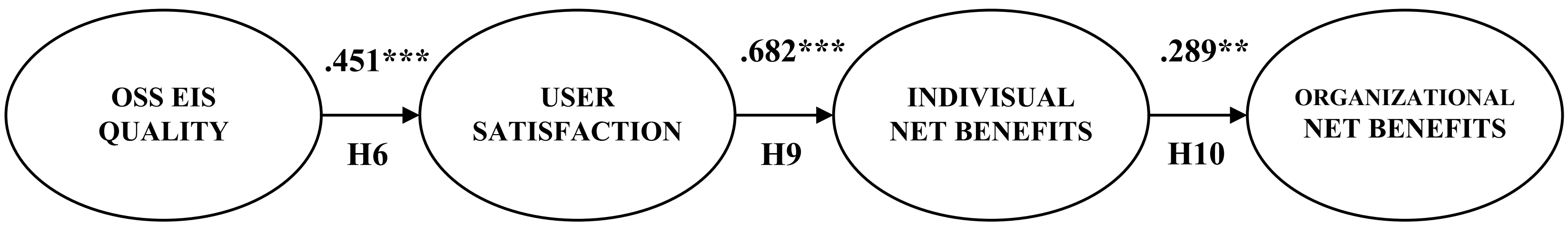
Management, Purchasing, Distribution/Logistics, Personnel/Human Resources, Asset Management, Maintenance, and R&D Management module. Interestingly, the result is quite similar to the result of prior studies on proprietary ERP (Mabert et al., 2000; Olhager and Selldin, 2003; Katerattanakul et al., 2006). However, it shows different ranks of ERP use from the ranks of a prior study by Olson et al. (forthcoming in 2010). In Olson et al.'s study the most downloaded OSS ERP module was the Maintenance module (51.10%) and Financial and Accounting was ranked 6th (13.70%). Plausible justifications on the results would be: (1) users download and try more supportive OSS ERP modules, such as Maintenance; however, they actually implement and use value adding modules, such as Financial and Accounting; (2) different locations of sample population – the survey was done on mostly Korean OSS EIS users and the content analysis was done in an on-line community of which most users are located in the US. The later justification is discussed in the limitation section of the study.

For the use of SCM modules, Data Management was highest. This study adopted the classification scheme built by McLaren and Vuong (2008). The definition of Data Management defined in their work includes XML, RFID, and EDI. A possible explanation of Data Management being the highest in rank would be the increasing use of RFID in supply chain management. The usage of OSS SCM modules implicates the increasing importance of RFID in supply chain.

Based on a vast amount of literature but essential reviews on EIS OSS, the model of this research was developed with three exogenous variables and four endogenous variables with 30 measured items. Then, the model was analyzed by SEM statistical technique, which has such advantages as its goodness for confirmatory research with: (1)

multiple dependent variables; (2) mediating variables; and (3) multiple group analysis (Lee and Lim, 2009). The software tool utilized for this research was AMOS 16.0.

The ambiguous definition of system use (OSS EIS Use) has been an issue in developing the IS success model and the result of this study also has the same issue. The study observed no significant relationships between OSS EIS Use and its two precedents, Information Quality and OSS EIS Quality. Moreover, the hypothesis between OSS EIS Use and Individual Net Benefit was not supported either. The results suggest removing the OSS EIS Use construct entirely from the OSS EIS model proposed by this research. Hence, a simplified model of OSS EIS success with only 4 construct can be rebuilt as shown in Figure 4.3.



*** P<.05; **p<.01; ***p<.001**

Figure 4.1 Suggested OSS EIS Success Model

CHAPTER FIVE

CONCLUSION

"In the beginning God created the heavens and the earth. (Genesis, 1:1)."

This chapter presents conclusions of the research. It consists of summary, limitations, implications, and future direction of the research.

5.1 SUMMARY

This study explored IS success models and factors in the OSS EIS context. The majority of constructs used in prior studies of IS success in general was developed in the 70's through 90's (Matlin, 1979; Melone, 1990; DeLone and McLean, 1992; Bonner, 1995; Ballantine et al., 1996; Gable, 1996; Kapalan and Norton, 1996; Myers et al. 1998). Examinations of IS success models in various context were conducted in the 90's and early 2000's (Seddon et al, 1999; Irani and Love, 2000; Lin and Shao, 2000; DeLone and McLean, 2002; Rai et al., 2002; Thatcher and Oliver, 2001; DeLone and McLean, 2003; Gable et al., 2003; Shin, 2003; Sedera and Gable, 2004; Sabherwal et al., 2006; Gable et al., 2008; Lee et al. 2009).

Typically, EIS are developed by proprietary vendors and OSS has been more successful in the non-enterprise level software sector. However, Grewal et al. (2006) claimed that proprietary vendors realize that OSS can be product lines for vendors as well as a threat in the proprietary enterprise system market. OSS EIS enable SMBs to implement EIS due to the minimal cost (Johansson and Sudzina, 2008) and provides the potential as a disruptive innovation. Yet, few studies have explored OSS EIS.

The present research was designed to confirm the effectiveness of IS success models and constructs that have been built by prior studies during the past three decades. Specifically, the study was aiming to build an IS success model by modifying the widely used models and factors, and investigate its validity and the effectiveness of its constructs in the OSS EIS context.

5.2 IMPLICATIONS AND LIMITATIONS OF THE STUDY

The overall objective of this study was to examine the relationships between IS success factors in the OSS EIS context. First of all, based on a comprehensive literature review of EIS modules, overall summary of EIS classification was presented by this study. EIS typically are implemented in modules. Analyzing the frequency of module use enables OSS EIS developers as well as users to have a better understanding of the maturity level of OSS EIS modules and, therefore, they know what to download. For researchers, the present research has expanded the IS success model to the OSS EIS context. For researchers, the present study has provided a comprehensive classification of EIS modules. Such classification, even though it has limitations, as discussed in the next section, is beneficial as a reference in studies of EIS.

Few empirical studies have been done for OSS EIS success. The present research has provided the practical evidence of effective relationships in the OSS EIS model. The developers in on-line OSS communities may take the success factor into account when they develop OSS EIS. The software development cycle (e.g., SDLC or Waterfall model;

Royce, 1970) can be viewed from the perspectives of the status of the OSS project. The present study also identified two distinct phases of the OSS project: development and diffusion. Not all OSS projects can be sustained in the on-line community and diffused to fields. More OSS projects end their SDLC in the development phase (Lee et al., 2009). The three milestones associated with the two phases are: project initiative, project sustaining, and project adoption.

Like all studies, the present research has some limitations. OSS is different from proprietary software in terms of its motivation, development process, social dynamics in the development group, and diffusion process, such as licensing issues. The present study of OSS EIS success has been mainly focused on only the user's perspectives, which are not the only potential considerations when adopting OSS EIS. Other limitations of the research include the process of data collection. Even though the study was consistent in both phases in terms of using the OSS EIS classification, the sample populations may potentially be different. The prior studies on proprietary ERP showed different results in three different countries (Mabert et al., 2000; Olhager and Selldin, 2003; Katerattanakul et al., 2006). Having a comprehensive EIS classification is both beneficial and limited, since the classification has not been validated using traditional research methods. This condition of study may result in a biased research design and consequences.

The small sample size could also be a limitation of the study. Due to the difficulty of collecting data from very rare population (OSS EIS users), only a minimal size of sample (N=150) was used in the study. A longitudinal study may supplement this weakness.

5.3 FUTURE STUDY

The present study of OSS EIS success has been mainly focused on only user's perspectives, which are not the only potential considerations that firms take when adopting OSS EIS. Future studies could expand the present research by being more inclusive and cover a broader scope of OSS EIS aspect to be more applicable in practice. As Brydon and Vining (2008) pointed out, OSSs are causing disruption in many wide-level systems, such as those in the ERP software market. In the OSS paradigm, multiple entities (individuals, organisations, academic institutions, and others) come together to develop a software product. OSS is not confined in the category of software products for only "low-level-system-oriented", as conventionally recognized.

A multiple group analysis is interesting when considering the context-sensitive character of OSS EIS. For group test and comparative analysis, SEM requires an adequate sample size. The present research collected 150 valid survey results, which is a minimal number of data when considering the number of constructs. Typically, SEM requires about 5 ~ 10 times the number of measured constructs (Kim et al., 2009). The model has 30 measured constructs. To execute a valid analysis, each group must have a data set of 150 at least. Two evenly divided the group (n=75) does not give the number of data recommended for SEM analysis. Hence, the present research was not appropriate to perform a multiple group analysis.

The present study performed some t-tests for multiple independent groups. The sample size was also a limitation for t-tests. For example, a t-test was intended to compare the mean value of the duration of OSS EIS use between large organizations with more than 300 employees and small organizations of less than 300 employees. As

Ghobadian and O'Regan (2000) suggested that firms employing less than 300 employees can be classified as SMBs, the respondents were grouped based on the number, which did not yield a balanced number of data in the two groups. The study had to adjust the cut point defining groups to 100, which is the next lower level in the questionnaire.

As discussed in the limitation section, a longitudinal study in different countries with the varying development states of IT and economic development can be a potential research topic in the future and also an answer for the limitation of sample size.

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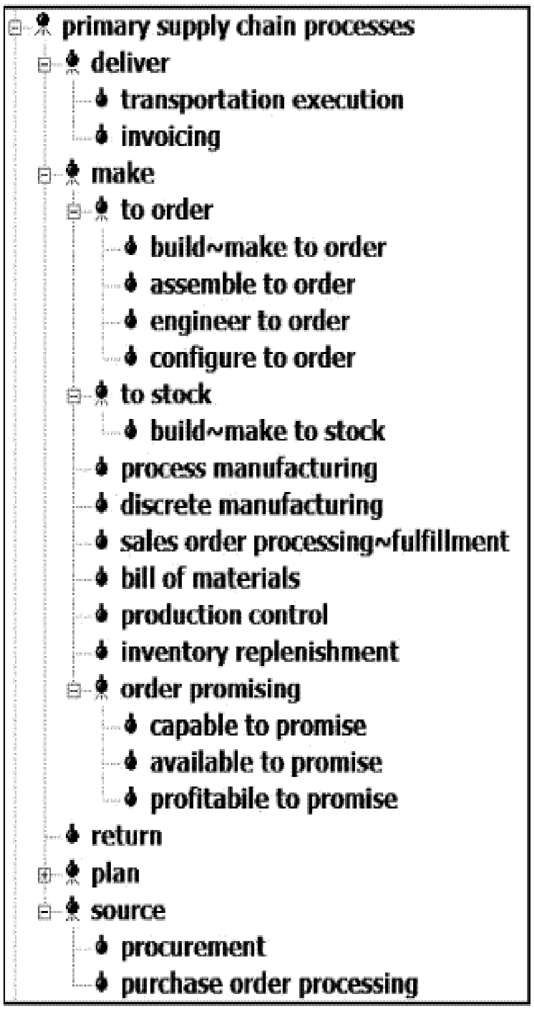
APPENDICES

APPENDIX A: SCM IS Functional Attributes by McLaren and Vuong (2008)

(With primary supply chain processes collapsed)



(With plan process group collapsed)

(Plan process group expanded)

APPENDIX B: Survey Questionnaire for OSS EIS

PART I General Questions/Organizational Characteristic

1. Gender
   a. Male
   b. Female

2. Age
   a. 19 ~ 29
   b. 30 ~ 39
   c. 40 ~ 49
   d. 50 ~ 59
   e. Over 60

3. What industry is your organization in?
   a. Manufacturing
   b. Financial
   c. Distribution
   d. IT/Communication
   e. Service
   f. Other (Please specify. E-Commerce, Energy, Heath, Education, Government, Individual, Student, etc.)

4. Approximate your organization's annual revenue (M = Million)
   a. 0 ~ $0.5 M
   b. $0.5 M ~ Less than $1 M
   c. $1 M ~ Less than $10 M
   d. $10 M ~ Less than $50 M
   e. $50 M ~ Less than $500 M
   f. Over $500 M

5. How many employees does your organization have?
   a. Less than 100
   b. 101 ~ 300
   c. 301 ~ 1000
   d. 1001 ~ 9999
   e. Over 10000

6. What country do you work at?

7. What is your job title?

PART II General questions about Open Source Software (OSS) Enterprise Information Systems (EIS)

Please answer the following questions based on OSS EIS in your organization.

1. How long has your organization used OSS EIS?
   a. Less than six months
   b. 6 months ~ 1 year
   c. 1 year ~ 2 years
   d. 2 ~ 5 years
   e. More than 5 years

2. Indicate the OSS EIS modules you have experienced. (Choose multiple items, if applicable.)

   ❖ Enterprise Information Systems (ERP)
      a. Financial & Accounting
      b. Materials Management
      c. Production Planning
      d. Order Entry
      e. Purchasing
      f. Financial Control
      g. Distribution/Logistics
      h. Asset Management
      i. Personnel/Human Resources
      j. Quality Management
      k. Maintenance
      l. R&D Management

   ❖ Customer Relationship Management (CRM)
      m. Channel Management
      n. Call Center/Help Desk
      o. Data Integration/Data Warehousing
      p. Knowledge Management
      q. Field

r. Sales
s. Marketing
t. Product Management

❖ Supply Chain Management (SCM)

u. Delivery (transportation execution, invoicing)
v. Make (to order, to stock, process manufacturing, discrete manufacturing, sales order processing, bill of materials, production control, inventory replenishment, order promising)
w. Return
x. Plan (demand planning, supply planning, service parts planning, supply and demand matching, optimize inventory, network design, production planning, transportation planning)
y. Source (procurement, purchase order processing)
z. Data Management (XML, RFID, EDI)
aa. Decision Support (optimization, reporting, modeling, forecasting, product lifecycle management, scenario analysis, simulations)
bb. Relationship Management (distributor, competitor, retailer, manufacturer, supplier)
cc. Performance Improvement (lean supply chain, performance analysis, collaboration, quality management)

3. What percentage of OSS EIS had to be customized to fit your organization's need?
   a. Less than 5%
   b. 5% ~ 10%
   c. 10% ~ 20%
   d. 20% ~ 50%
   e. More than 50%

4. Please indicate the extent to which you agree with the following statements.

   1=Strongly Disagree, 3=Neither Agree nor Disagree, 5=Strongly Agree

   a. OSS EIS was configured by experts.
      1 2 3 4 5

   b. We have experienced system performance problems due to the customization of OSS EIS we adopted.
      1 2 3 4 5

c. We have experienced software upgrade problems due to the customization of OSS EIS we implemented.

    1 2 3 4 5

d. System reengineering has taken placed as OSS EIS implementation proceeds.

    1 2 3 4 5

5. Who is involved in OSS EIS implementation for your organization?
    a. OSS EIS community
    b. Proprietary vendor
    c. 3rd party OSS EIS distributor
    d. Consulting firm
    e. In-house implementation

6. Who does provide the most technical support you need for OSS EIS?
    a. OSS EIS community
    b. Proprietary vendor
    c. 3rd party OSS EIS distributor
    d. Consulting firm
    e. In-house support

PART III OSS EIS User Perception

Please answer the following questions based on your experiences with OSS EIS in your organization.

1=Strongly Disagree, 3=Neither Agree nor Disagree, 5=Strongly Agree

Information Quality

Information quality refers to the quality of the information OSS EIS produces in reports and on-screen.

1. Information from OSS EIS is always timely

    1 2 3 4 5

2. Information from OSS EIS is always accurate

    1 2 3 4 5

3. Information from OSS EIS is always relevant to my tasks

1 2 3 4 5

4. Overall, OSS EIS information quality is satisfactory
   1 2 3 4 5

System Quality

System quality refers to the performance of OSS EIS.

1. OSS EIS response is always quick
   1 2 3 4 5

2. OSS EIS is easy to use
   1 2 3 4 5

3. OSS EIS has useful functions
   1 2 3 4 5

4. Overall, OSS EIS system quality is satisfactory
   1 2 3 4 5

Community Service Quality

The OSS EIS community services that you have experienced. Communities include on-line communities or partners who provide OSS EIS and/or supports to your organization.

1. OSS EIS community has up-to-date hardware and software
   1 2 3 4 5

2. OSS EIS community is dependable
   1 2 3 4 5

3. OSS EIS community gives prompt service to users
   1 2 3 4 5

4. OSS EIS community has the knowledge to do its job sell
   1 2 3 4 5

5. OSS EIS community has users' best interests at heart
   1 2 3 4 5

6. Overall, OSS EIS service quality is satisfactory
   1 2 3 4 5

OSS EIS Use

OSS EIS use is an indicator that shows how much you use OSS EIS.

1. I use OSS EIS very frequently (many times per month)
   1 2 3 4 5

2. I use OSS EIS very intensively (many hours per day)
   1 2 3 4 5

3. Overall, I use OSS EIS a lot
   1 2 3 4 5

User Satisfaction

User Satisfaction is your feeling about and response to the use of the output of OSS EIS.

1. The output information of OSS EIS is complete
   1 2 3 4 5

2. I am satisfied with the material design of the layout and display of the output contents from OSS EIS
   1 2 3 4 5

3. I have strong feeling of control over OSS
   1 2 3 4 5

4. Overall, I am satisfied with OSS
   1 2 3 4 5

Individual Net Benefits

Individual Net Benefits are concerned with how OSS EIS has influenced your individual capabilities and effectiveness on behalf of the organization.

1. I have learnt much through the presence of OSS EIS
   1 2 3 4 5

2. OSS EIS enhances my awareness and recall of job related information
   1 2 3 4 5

3. OSS EIS enhances my effectiveness in the job
   1 2 3 4 5

4. OSS EIS increases my productivity
   1 2 3 4 5

5. Overall, the impact of OSS EIS on me has been positive
   1 2 3 4 5

Organizational Net Benefits

Organizational Net Benefits are measures of the extent to which OSS EIS has promoted improvement in organizational results and capabilities.

1. OSS EIS reduces cost
   1 2 3 4 5

2. OSS EIS requires less number of staff then proprietary software does
   1 2 3 4 5

3. OSS EIS improves outcomes/outputs
   1 2 3 4 5

4. Overall, OSS EIS increases organizational productivity
   1 2 3 4 5

APPENDIX C: OSS EIS Projects in On-line OSS Communities

[ID]	[Title]	[ID]	[Title]	[ID]	[Title]	[ID]	[Title]
1	Nagios	41	openCRX	81	Open Eye	121	q4wine
2	Liferay	42	openXpertya	82	Rifidi	122	Active Sharedoc
3	vtiger	43	FrontAcc	83	Gazie	123	PhreeBooks
4	Oxygen	44	Bots	84	Yaoqiang	124	aster
5	Pentaho	45	Project.net	85	KH Coder	125	EBI
6	Openbravo	46	Maarch	86	WorldVistA	126	tellmatic
7	Zenoss	47	jBilling	87	TUTOS	127	uEngine
8	Jasper	48	Magnolia	88	Adempiere	128	Ooo
9	Openfiler	49	openQRM	89	Jitterbit	129	CloverETL
10	phplist	50	Joget	90	OpenI	130	The Daisy
11	MantisBT	51	VMukti	91	SuiteFlex	131	Real Estate
12	ZK	52	SOFA	92	hipergate	132	epesi
13	PostBooks	53	Plazma	93	eXo	133	yellow
14	LimeSurvey	54	NutWin	94	ControlTier	134	PalOOCa
15	Adempiere	55	PatientOS	95	OpenRPT	135	CK
16	Hyperic	56	OpenXava	96	MailArchiva	136	Rivulet
17	RapidMiner	57	XRMS	97	Activa	137	DaReManager
18	OrangeHRM	58	ASTRES	98	Adaptive	138	Precurio
19	webERP	59	Medical	99	ATA	139	SolidState
20	JasperServer	60	Epiware	100	PHD	140	Coupa
21	Feng Office	61	OpenReports	101	FreeCRM	141	ERP.NET
22	ProcessMaker	62	EGG crm	102	JAMWiki	142	BlueERP
23	CiviCRM	63	MindTouch	103	SIDU	143	Stock
24	Mondrian	64	Webacula	104	SymmetricDS	144	LedgerSMB
25	OpenEMM	65	SugarCRM	105	web2Project	145	DocumentB
26	HOSxP	66	nagstamon	106	LeanPM	146	h-inventory
27	]project	67	YAWL	107	Portaneo	147	DataCleaner
28	ISP Control	68	WeBid	108	Evaristo	148	Ganesha
29	Compiere	69	Jfire	109	FacturLinEx	149	Bill Maker
30	OpenKM	70	Executive	110	Support	150	th
31	Mibew	71	ManyDesigns	111	RunaWFE	151	RapidNet
32	Group-Office	72	Lokad	112	Kablink	152	WaypointHR
33	Talend	73	NConf	113	itop	153	cult
34	opentaps	74	Foswiki	114	Osmius	154	FreeAnalysis
35	TWiki	75	Palo Suite	115	queXF	155	MYIT
36	Dolibarr	76	LetoDMS	116	Limbas	156	Zimbra
37	SpringSide	77	Apatar	117	Tustena	157	The Naked
38	Sparklines	78	Neogia	118	OBPM	158	TinyERP
39	Turquaz	79	OneCMDB	119	TNT	159	Tribix
40	OpenEMR	80	PHP	120	Orange	160	jAllinOne

[ID]	[Title]	[ID]	[Title]	[ID]	[Title]	[ID]	[Title]
161	OTRS	201	StoryTestIQ	241	JClaim	281	JBoss
162	logicAlloy	202	Huru	242	BMC	282	Eastwood Charts
163	T-dah	203	NPS	243	bxModeller	283	Web Law
164	ProM	204	Tockit	244	NMail	284	ComUnion ERP
165	osCommerce	205	iPFaces	245	CottageMed	285	Sales Po
166	nature	206	MyErp	246	HELIOS	286	ADaMSoft
167	DataSync	207	Sinergia	247	Felix	287	Meta Clinic
168	Maximo	208	QDataMatrix	248	Contabilidad	288	OAJ
169	bflow	209	pERP	249	OpenPetra.org	289	FormFlow
170	faceCart	210	OpenSTA	250	i-doit	290	Zoapiere
171	Cream	211	Web Auction	251	jdbc4olap	291	Open
172	JPEd	212	IntarS	252	olap4j	292	Yaoqiang
173	Sistema	213	JTL	253	IDCMS	293	pyARS
174	Alchemi	214	frePPLe	254	BulkMailer	294	Freedom
175	Biwoo	215	ThinWire	255	Falt4 CMS	295	Item Invent
176	IntChat	216	C# ECG	256	SaberNet DCS	296	VtigerCRM
177	Oscar	217	DCM4CHEE	257	Legal Case	297	Zorkif
178	CRMFacil	218	GlobalSight	258	B2Stok	298	Cyn.in
179	Tender	219	ICeHrm	259	TAU	299	Systems Osiris
180	Bias	220	ConcourseC	260	Jmagallanes	300	KETL
181	FGMP	221	Free	261	Covide	301	Active Direc
182	Hospital	222	Ranchbe	262	AML	302	InfiniDB
183	Ubuntu	223	chellow	263	Main//Pyrus	303	ADHelper
184	Mantaray	224	Projectivity	264	GeoKettle	304	SpagoBI
185	Inforama	225	vtiger Brazilian	265	PyLiveResponse	305	TobFlow
186	IGSuite	226	OSGi	266	tinyManager	306	OrgCharter
187	FlashRecruit	227	ProM	267	AgilPro	307	OpenLSD
188	mendelson	228	time-o	268	Integria	308	VistA-Edge
189	Unified	229	Gardenia	269	OpenCustomer	309	Enterprise
190	OpenDataBag	230	Illunus Data	270	Palo	310	VOIP
191	CalemEAM	231	CiviSync	271	SourceTap	311	nanowawi
192	DB Browser	232	Payroll	272	Retailer.org	312	FNDLOADER
193	openMDX	233	openwms.org	273	OpenSource	313	Overactive
194	OpenIT	234	LucidDB	274	Medscribble	314	bitfarm
195	Millennium	235	jBeacon	275	RepairsLab	315	Abstract
196	myWMS	236	Commander4j	276	Organizers	316	Elexis
197	Open ERP	237	Rubik	277	Citrus Database	317	Ofbiz
198	Excel Bill	238	CentraView	278	jNFe	318	SimplePDF
199	WPMU	239	Ohioedge	279	PMbyAS	319	DCTM
200	Zksample2	240	xProcess	280	Open PI	320	1BizCom

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322	Toutateam	362	Education	402	Innovati	442	LATRIX
323	Ajexa	363	OpenBlue	403	Pretty Da	443	Teamcenter
324	OpenERP	364	Pentaho	404	cPanel	444	ADbNews
325	BarCode Ge	365	SAP BAPI	405	NEXUS	445	openAlerts
326	SAFMQ	366	XScheduler	406	Atricore	446	CoreMan
327	Barcode	367	OpenInfo3W	407	EMC	447	ITAnyplace
328	nexusbpm	368	Compiere	408	OpenXDAS	448	personal doc
329	QuickTicket	369	OpenEMR M	409	Starprise	449	OpenEphyra
330	Artikel23	370	bpmscript	410	CapitalReS	450	Encrypted
331	MyHook	371	APbyAS	411	TherapyDoc	451	Info Pool
332	IT Project	372	Projeto	412	eCTD	452	Rally
333	Simple Inven	373	Document M	413	Booking	453	MugShots
334	IiM	374	Socr3	414	cinnamon	454	Fisterra
335	OpenPCL	375	JoomCivi	415	Samooha	455	JELEN
336	Collabry	376	CiMe	416	iPoint	456	Olap Na
337	]project-op	377	Invoice	417	EVPO	457	Eberom
338	Monju	378	RUNick	418	Residential	458	Help Desk
339	Humano2	379	Web Tim	419	EHRflex	459	Olap
340	BizDiag	380	openMEDIS	420	OGSA-DAI	460	erpFram
341	ResCarta	381	Cisco IP	421	openCollab	461	Adempiere Pro
342	allocPSA	382	Symbolic	422	Ubuntu-B	462	Gerenciamento
343	PHPBo	383	mSeller	423	Suniant	463	OpenAppF
344	The Address	384	xsltcms.org	424	Popsicle	464	Datacleaning
345	BPMspace	385	EdgeERP	425	Flisys	465	taskcal
346	Cite	386	S.A.F.E.	426	MFbyAS	466	SBVR
347	Dove	387	Open Enter	427	koosseryADe	467	Prime
348	Auto, Car	388	Ramsetcube	428	Velo	468	Atabaque
349	Daffodil	389	SHINE	429	SONIVIS:	469	Workflow
350	OpenOLAP	390	GNUmed	430	Gateway An	470	Zanzi Info
351	X-RIME	391	JGuiGen	431	Information P	471	webems
352	SSLBridge	392	Communicati	432	Financial P	472	abanq.source
353	Data Qualit	393	OpenOffice	433	uOffice	473	Vtiger
354	Yonix DS	394	Cubulus	434	GWT	474	iglobalgest ERP
355	Xendra	395	ToilManager	435	RoosterIT	475	Password T
356	German	396	IPCC	436	OpenL	476	AGENCY
357	NewTranspo	397	once:radix	437	Active Ag	477	Racksmith
358	GenerateData	398	Hiitch	438	PhpVitae	478	SimplecoreLogic
359	Software Qua	399	Amix	439	OpenTT	479	KPInator
360	Teknologiap	400	OpenFakt	440	FIDAL	480	myCMMS

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482	Metron	522	Store M	562	SpaceBo	602	OPENSUITE
483	SimpleCRM	523	Compiere Jas	563	OLAP Spend	603	FitNet
484	Electris	524	Deep Email	564	Elyazalée	604	jRivet
485	bugTrack	525	OpenEAS	565	Mamook	605	JeNiFEr
486	WingS	526	CRM-Com	566	IRADIA	606	csv2odf
487	Open-MQ	527	Sistema	567	The Obix	607	Skrub
488	GAL	528	Openbravo P	568	Polo	608	BusinessWi
489	mydbaccess	529	3dVrmlStudio	569	Nmwerp	609	Mountain M
490	seta	530	MetaShare	570	Change M	610	ZFPPreno
491	C.A.T.	531	Recruit	571	Tariff Eye	611	ifriqiya
492	opendias	532	Physhun	572	Bookmarks	612	Plumber
493	KTiny	533	tyl-project	573	Biztalk X	613	Sfeb
494	Opalo	534	BMC	574	uEngine	614	Quick T
495	DocUpd	535	Java Busi	575	TracG	615	ERPJewels
496	Compiere Fix	536	DosIS	576	StarMX	616	BEXPSD
497	ER/Box	537	Yaoqiang	577	dmtxscan	617	Customer Su
498	TagCentric	538	Compiere	578	jointar	618	TraSer
499	Jataka	539	Proyecto	579	CloudI	619	The XE
500	e-NVISION	540	EnterTrack	580	Camaroes	620	HTMLT
501	Materio	541	Enterprise Ene	581	ChainBuilder	621	Monte Carlo
502	scan2pdf	542	FreeRetail	582	Jethro	622	Hibersap
503	ProMan	543	Passage .NET	583	Qualinnove	623	Helix PHP
504	taxi dispatcher	544	IOM	584	ETL	624	webMethods
505	OFBiz	545	ISO Con	585	jPersist	625	AbelCRM
506	SureInvoice	546	LAMP	586	AUCAS	626	CMS
507	GASwerk	547	Order Ent	587	IdMUnit	627	Tevere
508	Network Co	548	Data Migrat	588	Importal	628	OSBI
509	ERPLibero	549	infoERP	589	simtrain	629	ArgKit
510	Hotel Se	550	PSFGeneric	590	NobleCRM	630	Appointment
511	Tofu Sn	551	Open Leav	591	Easy Luce	631	Gestion de
512	myApps	552	ETL	592	Advanced	632	AnJelica
513	Knowledge B	553	Silverlight	593	Res	633	weka
514	Web Pu	554	Inventory Ma	594	Winds	634	Coral8
515	Oberon	555	MobileUS	595	Pequel	635	Boxi
516	flowchartwiki	556	jWebApp	596	Work T	636	HydraCube
517	APEX	557	Intrannuity iBi	597	Asterisk	637	VENSSO
518	web2proje	558	CMS	598	Open Proc	638	coffeeadmin
519	Coadunation	559	EEG	599	Ajuby	639	Structs And
520	Curl Lib	560	phpDHCP	600	SmartGRAPE	640	Remedy

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642	Modus	682	PeKaVau	722	DDELin	762	SCUTUM
643	EasyVZ	683	PHP Bu	723	Agenda	763	FreeERP
644	Postna	684	Pet	724	Compiere	764	Computer Ser
645	Picket	685	CRP	725	WSDL2XForms	765	Migration M
646	OO jDREW	686	ERPel	726	CLIGRAPH	766	Architect
647	OPEN S	687	Fuzzy Wors	727	Controle Int	767	jedi
648	RTK	688	TestCase4j	728	Compiere Ga	768	JRFramework
649	Webanizer	689	vTiger	729	SWAG	769	Open-Coman
650	Magento	690	H Plus	730	Procentro	770	MiniETL
651	DeciGen®	691	Sporkforge	731	DevEnhancer	771	OpenOps
652	Electronic	692	DACAD	732	JasperTags	772	2pack
653	Candidates	693	Jasper	733	Innovation L	773	FormatCh
654	Warehouse	694	eZimDMS	734	OpenCompiere	774	Business Proc
655	State Mach	695	Gdarim	735	Project Ar	775	wxQueries
656	Business Pr	696	Enterprise	736	GEStione	776	eSupportCenter
657	JQBridge	697	La_Azada	737	a web base hrm	777	Hotel de Java
658	TRAK	698	Gnome	738	Team Ele	778	Studienportal
659	OrangeGears	699	MvxLib	739	Gestión	779	Checklist
660	Dentax	700	henglian	740	Check Up	780	Metadata
661	AMB	701	PhpGdStock	741	Sarman	781	Jibe Frame
662	OAC	702	Open S	742	Pathfinder	782	B2B by P
663	openDigger	703	iCognition	743	TRAK	783	jOpenIT
664	Hireway	704	wizard4j	744	SPASE	784	ServiceMa
665	PICI	705	FreeDEM	745	EFF	785	Zeppelin
666	Amped Repo	706	OSSUITE	746	NetOffice	786	Smart
667	Breadboard	707	Multi Pass	747	HailStorm	787	OpenMigrate
668	J2easy	708	OpenURP	748	eBrigade	788	Top Store
669	OpenOMS	709	COBOL Da	749	Workbench	789	Chomoko
670	X Se	710	SalesLeader	750	O3-XDS	790	Protoforge
671	NARC	711	ctl-dispatch	751	Quicklogs	791	Umax
672	B.Sync	712	AnnualLeave	752	MixDEM	792	ZappWeb
673	Open Blackb	713	SBeaVeR	753	XBR	793	DropboxMQ
674	FleaIM	714	HSC	754	qnetwork	794	Toolkit e-f
675	Gestor	715	Java Da	755	Hillmaker	795	ODBIS
676	nbpm	716	tux_oracle	756	TSMtape	796	OTRS
677	Jetfire	717	Util Abanq	757	FreeOlap	797	CSTracker
678	Killtrojan	718	IRMA	758	Web Ser	798	dotii
679	car repair	719	NVBase	759	Svarog	799	MiningMart
680	ekkes-corner	720	Yelo	760	ACMS	800	Rails

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802	ContactsDB	842	Mazeme inv	882	easyDE	922	Easy SOA
803	IPD&apo	843	gesmon	883	MeMo	923	SYMBOL
804	OpenAviation	844	Opacus	884	activeinsight	924	Vtiger Turk
805	MARVELit	845	Localization A	885	tbvs	925	CRMmart
806	Light W	846	CapaQuini	886	Gingkgo	926	OWB
807	Sistema	847	OpenDental	887	IT-Dep	927	AlchemySOAP
808	COS-HMS	848	Jlue	888	filofant	928	JOD S
809	EasyBI	849	Auxrames	889	OpenADM	929	Key-med
810	Gestion de	850	ZigBee	890	Merlin	930	smBackup
811	Web Li	851	Yoxel Sy	891	XMLToa	931	PyPcrm
812	PDF spli	852	FideliGes	892	BondsPric	932	Lucidium
813	TRAK	853	Business Co	893	Partystic S	933	JBELT
814	OpenTender	854	Portal Em	894	TinyERP	934	Meet#Web
815	onBI	855	MQ	895	BLAX!	935	Automated p
816	Business C	856	iceB	896	exby	936	small scale
817	RouteMe	857	NMTools	897	KS2D	937	WaterSnake
818	phpEWS	858	Userbase	898	Sure	938	SAP XI
819	Avalanche	859	SMARTDataB	899	WyattERP	939	NSIS
820	PUDI	860	QueWeb	900	BEE	940	eMarket
821	P2P sw	861	java issue	901	obsched	941	SprinxCRM
822	PlanningRH	862	Simple Statio	902	Compiere	942	ESM
823	guNa	863	TimeTrix	903	Whitebag	943	Maximo de
824	openDMS	864	Talend	904	ht	944	Cibet
825	ISP-Su	865	Postgres 8.1	905	Mambo	945	Zyuras
826	Arbeitsgruppe	866	JMrTools	906	Compiere	946	e-school
827	phpFreeLog	867	Spy 007	907	Gnu Intern	947	Kinabalu
828	Interna	868	red2	908	GOLEM	948	ScutMonkey
829	WeQuest	869	semantichrm	909	Pegasus	949	FUN
830	WFRecfgA	870	SnapLogic	910	Midas EDS	950	safety manage
831	CentraView	871	Ortro	911	Data Atlas	951	siages
832	HSC Cha	872	qb4j	912	SAFET	952	ALiVE
833	FOXOpen	873	ALTER	913	Compiere	953	adamo
834	candy	874	xanders:one	914	FeedRadar	954	monket
835	The Linux C	875	Aedilis	915	The ISSU	955	HBLA
836	Open Web	876	MyMixedPro	916	LA/OpenBP	956	GoogleCal
837	SameDesk	877	IST-Contract	917	ECONZ	957	Shared OFBiz
838	backup	878	TreeData	918	ObjeGts	958	PentahoLooker
839	Conception	879	fantastic	919	GabaSys	959	Lite Outbo
840	BPM Suite	880	pypes	920	MIND	960	GlobalCli

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961	B-Flow	1001	Catnip	1041	JS4J	1081	Workflow
962	AxcotoCart	1002	datablender	1042	Commius	1082	DOCS
963	DB2RDF	1003	IS Manager	1043	SQL	1083	Right F
964	OpenCSP	1004	Simulation	1044	The Hotwire	1084	Mule C
965	LSG	1005	ZuckerDocs	1045	SimpleWFS	1085	trauma-registry
966	GSi	1006	ERPBr	1046	WEB SE	1086	Main/
967	OpenMoka	1007	Raistlin	1047	Galicia	1087	pyter
968	Sharedlog	1008	License	1048	MSQueue	1088	Lyna
969	WSRP	1009	dvrmodel	1049	FUSION	1089	OFBiz
970	ci4free	1010	UPS P	1050	uMonitor	1090	Exclusive A
971	russian-na	1011	GO	1051	Variable D	1091	XMLBridge
972	AWStats	1012	wekatransform	1052	Simpledoc	1092	911 Cal
973	Phreebooks	1013	Etailer	1053	OCF	1093	XMyStats
974	Spatial Kn	1014	Silicon F	1054	TextLine	1094	Mystic
975	Softntic	1015	Check	1055	zbierania	1095	KOSBI
976	KeoFleX	1016	The Patchy	1056	SMEG	1096	Werkplaner
977	.NET survey	1017	OpenXL	1057	{IBA}	1097	CDP&NETSEC
978	SQuirreL	1018	office ad	1058	Tibco JMS	1098	Graphical
979	JGenesis	1019	BW	1059	MyRx	1099	Sustainable
980	useGA	1020	AIRPort	1060	NEXUSe2e	1100	ActiveHealth
981	Scout Tra	1021	Webswell	1061	Jather	1101	SugarDbLib
982	dotCMS	1022	Datapture	1062	Magellan	1102	Provision
983	Le fil	1023	BlueOxygen	1063	HELIOS	1103	OpenBizMap
984	Ra Survey	1024	OWL	1064	Fat Free	1104	Valid tiny-erp
985	FreeQuery	1025	Gentoo	1065	Health I	1105	Alloc
986	DRFOX	1026	Jasper Rep	1066	Info-Gest	1106	jSemanticS
987	Wood	1027	Fastaddr	1067	Imixs	1107	ShifTracker
988	Hermine	1028	Tornado	1068	PerMoTo	1108	BMC
989	webETB	1029	Goshawk	1069	PanBI	1109	SDG
990	NextGRID	1030	smblaunch	1070	Kukki	1110	LightSpeed
991	vTiger	1031	Topic Map	1071	Bizplizit	1111	SYR<=>SPR
992	työvuorolista	1032	Ocomon	1072	red-open	1112	SPASE
993	mopore-togo	1033	Artifact	1073	sWIB	1113	SPASE
994	flexmonitor	1034	Java Serv	1074	tbvs-hr	1114	Ikasan
995	FUSION	1035	OPENCITI	1075	Cgest	1115	CrossDef
996	METAjour	1036	Gemma	1076	Spire	1116	The Collective I
997	webstat	1037	Corinis	1077	Jipes	1117	EASD@Linux
998	LDS	1038	Work2Go	1078	pose	1118	setCampaignV
999	MAX	1039	Forth Vall	1079	SunshinePHP	1119	Shine ISP
1000	VMstato	1040	facturaSCR	1080	Productor	1120	Planning Star

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1121	BiWeVeExt	1161	Enterprise Me		**Launhpad**		**TuxFamily**
1122	GDGA_Aduit	1162	season	1201	Manufacturing	1200	c3s
1123	Question	1163	Kommerce	1202	IMS St		
1124	OFBiz	1164	Population	1203	InventJ		
1125	HIATLANTIS	1165	BREIN	1204	Kanban		
1126	Vietnamese	1166	iCat	1205	pyInventory		
1127	OpenJCS	1167	uBrain	1206	maven-		
1128	runus	1168	waterfalls	1207	OQUMA		
1129	Evolve-IT	1169	A2	1208	Contab		
1130	ootbes	1170	POOL	1209	MySQL		
1131	Transcoding	1171	Bletaco	1210	tinyerp		
1132	Kwantu	1172	OpenYard	1211	CiviCRM		
1133	SPA-ERP	1173	DIY Reports	1212	myEnterprise		
1134	Transparent	1174	Cont	1213	PostBooks		
1135	mod2chat	1175	obel-bundles	1214	Adempiere-L		
1136	idasdiners	1176	HRMS	1215	cirusdb		
1137	Farus	1177	zero	1216	Paracelso		
1138	Guise	1178	On the Clock	1217	Tango CRM		
1139	HyperLin	1179	filexform	1218	SugarCRM		
1140	Meadow	1180	scpfw	1219	Tine 2.0		
1141	Orbit	1181	Q-ERP	1220	Web B		
1142	LRU	1182	SiS	1221	Queplix		
1143	SpiceHire	1183	OpenSLS	1222	Cserve		
1144	ActiveBPEL	1184	ATrans	1223	Little Ent		
1145	Resort D	1185	AI-CRM	1224	Sphere-ERP		
1146	EDI Knight	1186	Structural	1225	Teliose-ERP		
1147	iAppSpace	1187	ComponentD	1226	Transport V		
1148	perpo	1188	Sushka	1227	Open ERP		
1149	YACRM	1189	Compare Dat	1228	webERP		
1150	ORDS	1190	Social N	1229	Invoicing/B		
1151	EximExpress	1191	Aplicación	1230	AmaniERP		
1152	FooMarker	1192	Outsourcing	1231	Osirails		
1153	Gestion	1193	BMC	1232	Openbravo		
1154	Super Tro	1194	phlow	1233	Leuk		
1155	SIBEP	1195	Obelix				
1156	PHPFFE	1196	knowhow				
1157	SIMPEG	1197	Open B				
1158	Hotel a	1198	taskdesk				
1159	OSS Pro	1199	GrupoC				
1160	RSS						

APPENDIX D: Project Title and Description in On-line Community